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DECEMBER 1918

SOCIETY WINTER MEETING
VICTORY DINNER
NEW YORK
FEBRUARY 4-6

SOCIETY OF AUTOMOTIVE ENGINEERS INC.
29 WEST 39TH STREET NEW YORK

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WINTER MEETING IN NEW YORK FEBRUARY 4-6 (NOTE CHANGE IN DATES)

A KEEN observer of national affairs has said that if the crisis involved in demobilization of war industry can be weathered with wisdom, the United States faces a period of the greatest pros-

perity in its history. The country is now producing its own merchant marine. Good roads building is expected to attain an unprecedented impetus. New industries will rapidly assume prominent posi-

TENTATIVE SCHEDULE Annual Meeting of the Society

New York, Feb. 4-6

(These dates have been decided upon as a matter of convenience to members who desire to attend also the Passenger Car and Truck Shows which it has just been announced will be held in New York February 1-8 and February 10-15.)

Standards Committee Meeting, Tuesday, Feb. 4

Business and Professional Sessions, Wednesday, Feb. 5

Section Officers' Meeting, Wednesday Evening, Feb. 5

Professional Sessions, Thursday, Feb. 6

Victory Dinner, Thursday Evening, Feb. 6

Papers dealing with every branch of automotive engineering, with probably the following among other subjects:

Aircraft and Aircraft Engines

Automobiles, Present and Future

Motor Trucks, Lessons Learned from Their Use in War

Tractors for Farm and Road Use

Motor Patrol Boats and Their Engines

Stationary and Farm Engines, Large and Small

Motorcycles for Delivery and Messenger Service

Fuels and Materials of Engineering

Tanks and Other Special Automotive War Apparatus

tions among the most important in the country.

The country has sustained the shock of peace in an extremely creditable manner and is making plain that the Government shall view the problem before it in the same dispassionate, calm way, that a well-ordered and definite program can be mapped out as soon as possible in exercise of common sense.

The Government has turned out over 500 ships, aggregating 3,000,000 deadweight tons, and 13,000,000 tons more are to be built. This indicates the scope of the statistics of the great conflict. In 1914 the world's deadweight mercantile tonnage was roughly between 70,000,000 and 75,000,000.

In the armistice phase Government and industry have foreseen what general conditions would prevail and have prepared to meet them.

Most of us have done some form of national service. Many of our fellow citizens have made mistakes. The other fellow always does. We have seen strength of character and demonstrated ability, unconditional loyalty and determination to prosecute the war to victory.

On the Marne American breasts helped to bar the road to Paris; on the Meuse American hammer-blows helped to shatter the pride and power of German militarism. The whole history of America's services to the Allied cause was summed up by Foch. First there was the critical day last March when, "stirred by a generous impulse, you came and placed at my disposition the entire resources of your army." Then there arose an American Army.

Victory Dinner

THE Victory Dinner will be held on the evening of Feb. 6. In attendance and interest it should break all records of the Society. The order of the evening will be rapid-fire talks, as at Dayton, by

those the members will like best to hear. The time is ripe for, demands, the greatest gathering of S. A. E. members. Men will talk who have not talked in public before, and men will tell of things they have not told of before. President Remington of the Institution of Automobile Engineers of Great Britain has pointed out, "The manufacture of aircraft, which, as regards its scientific and constructional side, is very largely the production of a combination of effort between the automobile engineer and the physicist, has been as regards its engineering requirements mainly provided for from the personnel of the automobile industry, so that when we consider this and also take into consideration the transport lorries, staff cars, tanks, motor boats, and petrol engines for wireless and all manner of other purposes, we begin to see the magnitude of the effort that has been made and is now being continued by the automobile engineer and his associates"—that is, the automotive engineer.

An outline of the Carry Through Meeting of the Society is given on the previous page.

Automotives Carry Through

THE Automotives carried through. The winter meeting of the S. A. E. to be held in New York, Feb. 4-6, is in recognition and continuation of that.

Illuminating technical sessions on the different automotives, including fuels, airplanes, tractors, boats, trucks—real engineering points alongside accounts of experience at the front—will be held on Feb. 5 and 6.

The references to meetings of the Standards Committee and the Society in January on page 389 were printed before the dates of the meetings had been changed to come in the week of the Passenger Car Show to be held in New York, Feb. 1-8.

CLOSING THE WASHINGTON OFFICE

THE Washington office of the Society in the Munsey Building, having served its purpose, has been closed. The reason for the closing, cessation of hostilities and the probable end of the war, could not be a more welcome or happier one.

By and large, the work of the office is represented or indicated by the Service List of the Society, which appears in this issue of the JOURNAL in the most accurate form it has been possible to prepare it.

The tasks at the Society headquarters in the national city have been arduous. Assistant Secretary Chase, who has been in charge, is deserving of much thanks for the conscientious and effective manner in which he has given attention to many subjects and items of work often com-

plex and novel in character. This applies to not only the office work but the cooperative duties he undertook with the Bureau of Standards and the National Advisory Committee for Aeronautics.

It is highly gratifying to record that the Washington staff has met with unfailing courtesy from the Government officials, including those associated with such bodies as the Council of National Defense.

Not the least pleasant event in the detailing of members of the Society staff to Washington is the remarkably spontaneous and extensive demand for the establishment of a Section of the Society there. The spirit of this is well defined by the remarks of Admiral Taylor and Colonel Orton which appear in substance on another page.

Some Experiments on Notched Bars

By CAPTAIN H. T. PHILPOT

THE primary object of the experiments dealt with in this paper was to obtain suitable dimensions and shape for a round notched bar test piece which could be used in acceptance tests on heat-treated steels in place of the standard square type. A test piece. Under present conditions the pressure of work on milling and shaping machines is such that it appeared desirable to remove the machining of notched bar test pieces from such machines, and the first object of these experiments was to obtain a test piece which could be produced entirely in an ordinary lathe.

It will be seen later that the round test piece, type M, fulfills the above conditions with sufficient accuracy and can be produced entirely by a lathe, the notch being made by turning in an eccentric mandrel. This mandrel has one disadvantage, in that it must turn through 360 deg., and the machining of the test piece takes place during about 24 deg. of this motion. This objection can be partly overcome by mounting four test pieces in the mandrel; but an alternative specimen, designated as type N, has been devised, in which the notches in the round test piece can be milled or shaped, in place of turning them in the eccentric mandrel.

In the early experiments it was found that while the radius at the base of the notch or groove had only a small influence upon the results obtained from steels which had been correctly heat-treated, its effect was very considerable on steels which had been either incorrectly heat-treated intentionally or which were in an untreated condition. This fact became evident in the experiments on round-grooved test pieces. It was, therefore, considered desirable to investigate the question as to whether the radius at the base of the notch had a similar effect when square test pieces were used.

The later experiments on square test pieces, types P and Q, tested in the Izod machine, and types U and V,

The paper from which extracts are given below was read at a meeting of the Institution of Automobile Engineers of Great Britain, April 10, 1918. The author, who is connected with the Aeronautical Inspection Directorate, British Ministry of Munitions, has received the Crompton medal, which is awarded annually by the Institution for the best paper read at its meetings.

The notched bar or so-called impact test was not until recently included in any American specifications and at the outbreak of the war several objections to this test were made by British steel makers. This condition led to the appointment of two research committees, one by the British Engineering Standards Association and another jointly by the Institution of Automobile Engineers and the Society of Motor Manufacturers and Traders. As a result of consequent researches, the single notch test piece of the Izod pendulum testing machine was standardized and the practical value of and necessity for the notched bar test made under standardized conditions have been acknowledged by British steel makers.

In addition to Captain Philpot's paper, another dealing with the notched bar test was presented by G. Charpy and A. Cornu-Thenard before the Iron and Steel Institute. In discussing the latter paper Walter Rosenhain (British National Physical Laboratory) stated that he had yet to find an example of a piece of steel which had really behaved badly in practice and given a good impact figure. Albert Ladd Colby in a report on British specifications for aircraft steels stated that he was shown many instances in which two lots of the same steel, after having received supposedly the same treatment and giving identical results by chemical analysis, tensile strength tests and microscopic examination, gave different values when subjected to the Izod test, which convinced him that the notched bar test is a necessary additional requirement for such steels as are used in aircraft production.

tested in the Charpy machine, confirmed the results which had previously been obtained upon the round-grooved specimens.

Certain of the experiments, such as those dealt with in Series XVII, XVIII, XXIII, XXIV, XXIX, XXX, XXXII, XXXIII, XXXIV and XXXV, showed clearly that it is possible to obtain widely different values from the notched bar test pieces with practically the same tensile test results on two pieces of the same steel which had been differently heat-treated, when the tests on the notched bars are made in a machine of the pendulum type. It was, therefore, considered advisable to make a series of experiments on notched bars in which the test consisted in the slow bending of the notched bar in a machine which had none of the characteristics of a shock or impact machine. It is interesting to note that in all cases the slow-bending test gave results showing similar variations in the two conditions of the steel, although the actual energy absorbed by the specimen was not equal to that which was absorbed when the test piece was broken in a pendulum machine.

MACHINES EMPLOYED

Most of the tensile tests reported in this paper were made on a 30-ton Denison single lever machine, and a few others were carried out on a 100-ton Buckton single-lever machine. In the majority of the tensile tests which are reported in Table 1, an extensometer was employed for obtaining the strain, in order to determine the true limit of proportionality. The elastic limit was not determined, as this involves continual running back of the load to find the point at which permanent set first occurs in the specimen.

The yield point was determined in accordance with the Engineering Standards Committee definition, which is quoted at the foot of Table 1. The elongation given in the table was in each case measured on a gage length



IZOD PENDULUM MACHINE WITH PENDULUM IN POSITION FOR RELEASE. THE POSITION OF THE TEST PIECE IS INDICATED BY X, WHILE AN ENLARGED VIEW OF THE TEST PIECE, VISE AND PENDULUM WEIGHT IS GIVEN IN THE INSERT

equal to four times the square root of the area.

The Izod testing machine used is of 120 ft.-lb. capacity, and the knife edge of the pendulum was arranged to strike the test piece at a distance of 22 mm. above the top of the vise. The center of the notch or groove was in all cases placed level with the top of the vise. To carry out the tests upon the round specimens special grips were made and were used in place of the grips supplied with the machine.

As the Charpy pendulum machine is not as well known in this country (England) as the Izod machine, it appears desirable to give somewhat fuller particulars.

Weight of the pendulum	22.770 kg. = 50.2 lb.
Height of fall of the center of gravity of the pendulum	1.3175 m. = 51.9 in.
Radius to the center of gravity	0.692 m. = 27.2 in.
Angle of fall corresponding to the height	154 deg. 41 min.
Distance from the axis of suspension to the center of test piece	0.750 m. = 29.5 in.
Radius to center of percussion	0.770 m. = 30.3 in.
Velocity of blow	5.082 m. per sec. = about 16.67 ft. per sec. { 30 kgm. = about 217 ft.-lb.
Total energy of blow	

The results obtained from the tests in this machine have been quoted in foot-pounds in order that they may

TABLE I—TENSILE TESTS

Material	Heat Treatment	Diameter of Test Piece, Inches	Gage Length, Inches	Limit of Proportionality	Tons per Square Inch		Elongation	Reduction of Area
					Yield Point	Ultimate Stress		
Series XVII Nickel Chrome Steel Bar SS1	Correct	0.276	0.98	40.4	47.8	55.5	28.5	Per Cent
	Incorrect*	0.277	0.98	39.6	45.9	54.3	26.5	Ft.-lb.
Series XVIII Nickel Chrome Steel Bar SH1	Correct	0.274	0.97	34.8	44.0	59.3	26.0	64.0
	Incorrect*	0.275	0.97	34.8	45.0	60.3	23.0	78.0
Series XIX Nickel Chrome Steel Bar A	Commercial	0.564	2.0	56.0	60.9	21.0	59.2	63.7
								8.0
Series XX Nickel Chrome Steel Bar E	Commercial	0.564	2.0	48.4	58.3	22.0	61.5	69.9
								57.7
Series XXI Carbon Steel Bar C	Commercial	0.564	2.0	28.0	39.1	30.5	54.6	82.9
								12.0
Series XXII Bright Drawn Mild Steel Bar D	Untreated	0.564	2.0	36.0	37.0	24.0	59.2	81.7
								14.8
Series XXIII Nickel Chrome Steel Bar SS3	Correct	0.564	2.0	26.0	44.0	54.9	26.0	67.0
	Incorrect*	0.564	2.0	35.2	44.0	54.3	24.5	64.0
Series XXIV Nickel Chrome Steel Bar SH3	Correct	0.564	2.0	25.0	44.0	59.1	25.0	63.0
	Incorrect*	0.283	1.0	24.0	44.0	61.8	22.5	58.0
Series XXV Carbon Steel Bar G	Commercial	0.564	2.0	18.0	25.2	38.5	33.0	56.0
								79.3
Series XXVI Nickel Chrome Steel Bar B	Commercial	0.564	2.0	44.8	55.6	59.8	23.0	62.0
								59.9
Series XXVII Nickel Chrome Steel Bar F	Commercial	0.564	2.0	38.0	54.0	61.6	23.0	56.0
								24.6
Series XXVIII Bright Drawn Mild Steel Bar H	Untreated	0.564	2.0	0.0	36.0	37.4	22.5	58.0
								9.6
Series XXIX Nickel Chrome Steel Bar SS5	Correct	0.212	0.75	32.3	44.3	55.2	26.7	69.5
	Incorrect*	0.211	0.75	31.9	42.1	53.8	29.4	68.5
Series XXX Nickel Chrome Steel Bar SH5	Correct	0.211	0.75	31.4	44.7	58.5	25.4	63.7
	Incorrect*	0.214	0.76	27.4	44.2	60.2	22.7	56.0
Series XXXI Nickel Chrome Steel Bar CN	Correct	0.564	2.0	42.4	53.4	27.7	64.0	60.6

be easily comparable with the values obtained from the Izod machine. The factor of conversion which has been used in working out these values is 1 kgm. = 7.233 ft.-lb.

The Brinell machine was employed for making the slow-bending tests on notched bars in connection with a number of the later series of experiments. A short sleeve ending in a rounded knife edge was fitted to the piston rod of the Brinell machine for applying the load to the test piece. The Brinell microscope was mounted upon the support in order to read the deflection of the specimen. The readings taken in the Brinell microscope were read against a moving scale attached to the sleeve on the end of the piston rod. A span of 44 mm. was adopted, equal to twice the striking distance of the knife edge of the pendulum above the top of the vise in the Izod machine. This span was used in order that the relative amounts of energy absorbed by producing shear stresses and tensile stresses should be approximately the same as in the test made in the Izod machine.

SOME EXPERIMENTS ON NOTCHED BARS

TABLE I—TENSILE TESTS

Material	Heat Treatment	Diameter of Test Piece, Inches	Gage Length, Inches	Tons per Square Inch		Elongation	Reduction of Area	Average Izod Notched Bar Test Result on Standard Test Piece, Type A
				Limit of Proportionality†	Yield Point‡			
Series XXXII Nickel Chrome Steel								
Bar X1.	Correct	0.424	1.5	39.0	60.8	Per Cent	Per Cent	Ft.-lb.
Bar X2.	Incorrect*	0.424	1.5	41.8	60.4	22.0	54.8	50.6
Bar X2.						22.7	59.6	12.6
Series XXXIII Nickel Chrome Steel								
Bar 1.	Correct	0.399	1.5	27.2	44.0	59.6	22.7	60.1
Bar 2.	Incorrect*	0.400	1.5	28.7	43.0	58.1	22.7	56.7
Bar 3.	Incorrect with Bar 2, and afterwards correctly treated as for Bar 1	0.400	1.5	31.9	45.8	61.1	22.7	60.2
Series XXXIV Nickel Chrome Steel								
Bar 4.	For heat-treatment see Table 3.	0.283	1.0	28.0	48.8	59.6	24.0	59.5
Bar 5.	For heat-treatment see Table 3.	0.424	1.5	29.0	47.2	61.5	23.3	61.0
Bar 6.	For heat-treatment see Table 3.	0.423	1.5	29.0	45.5	59.1	23.3	60.4
Series XXXV Nickel Chrome Steel								
Bar 7.	Correctly treated	0.424	1.5	28.5	44.8	55.9	24.7	63.8
Bar 8.	For heat-treatment see Table 3.	0.399	1.5	26.0	42.0	55.0	23.3	62.3
Bar 9.	For heat-treatment see Table 3.	0.399	1.5	32.0	44.5	56.0	22.7	58.9
Series XXXVI Carbon Steel								
Bar 35.	Commercial	0.565	...	18.0	34.7	43.3	27.0	67.8
Series XXXVII Carbon Steel								
Bar 45.	Commercial	0.565	...	32.7	35.9	46.5	30.0	65.4
Series XXXVIII Nickel Chrome Steel								
Bar 3B.	Commercial	0.424	1.5	32.0	48.5	58.3	25.3	65.8
Series XXXIX Nickel Chrome Steel								
Bar 4B.	Commercial	0.424	1.5	25.0	39.8	49.2	26.0	65.3
Series XL Nickel Chrome Steel								
Bar 3V.	Commercial	0.425	1.5	42.0	59.4	72.0	19.3	53.4
Series XLI Nickel Chrome Steel								
Bar 4V.	Commercial	0.424	1.5	36.0	55.8	65.7	21.3	59.8
Series XLII Nickel Chrome Steel								
Bar 3J.	Air hardened	0.424	1.5	25.0	...	124.5	10.7	28.0
Series XLIII Nickel Chrome Steel								
Bar 4J.	Air hardened	0.424	1.5	21.0	...	105.2	10.7	34.0
								0.4

Bars A, E, B, F, CN, 3B, 4B, 3V and 4V were commercially treated nickel chrome steel bars taken from stock.

Bars C, G, 3S and 4S were commercially treated carbon steel bars, taken from stock.

Bars D and H were untreated bright drawn carbon steel bars, taken from stock.

Bars SS2, SH2, SS4, SH4, SS6, SH6, X2, 2 and 4 were incorrectly treated intentionally to obtain low notched bar test values.

†The "limit of proportionality" referred to in Column 5 is the load per square inch of the original area at which the strain, as measured by an extensometer, ceases to be proportional to the stress.

‡The "yield point" given in Column 6 has been taken as defined by the British Engineering Standards Committee—"Practical Definition of Yield Point"—The yield point is the load per square inch at which a distinctly visible increase occurs in the distance between gage points on the test piece, observed by using dividers or at which, when the load is increased at a moderately fast rate, there is a distinct drop in the testing machine lever, or, in hydraulic machines of the gage finger.

NOTE—A steel test piece at the yield point takes rapidly a large increase of extension amounting to more than 1-200 of the gage length.

The "ultimate stress" is the maximum load divided by the original area of cross-section of the test piece.

TYPES OF NOTCHED BAR TEST PIECES

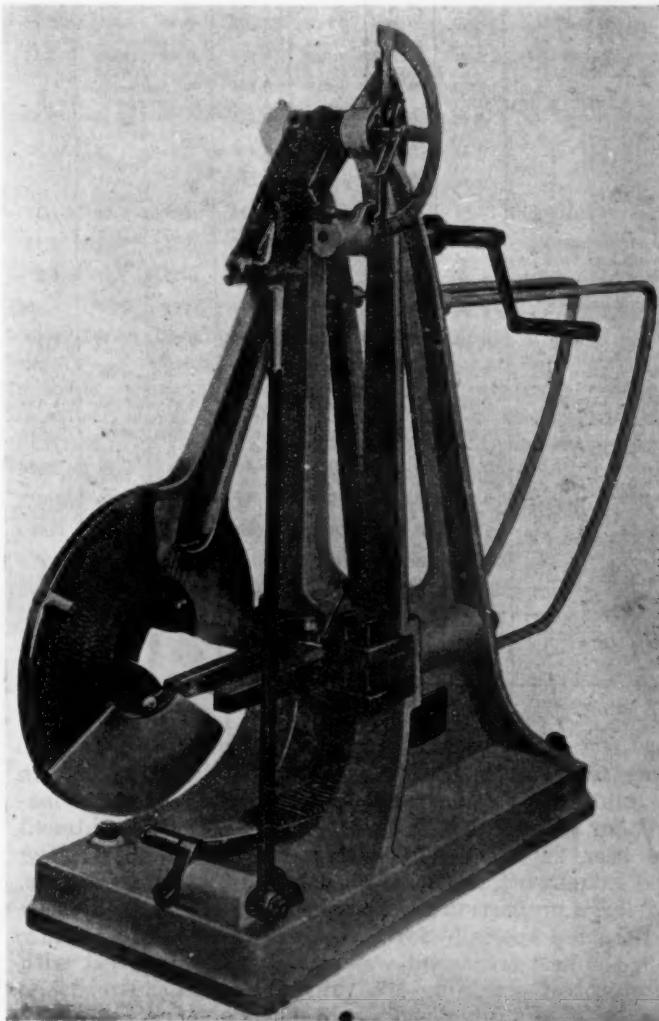
The shape and dimensions of the different types of notched bar test pieces which have been used in these experiments are shown. The standard square test piece, type A, was first standardized by the Aeronautical In-

spection Directorate, in consultation with the Steel Research Committee, in 1916, and was later adopted by the Air Board. This test piece is referred to as the standard square test piece throughout the paper.

The notched round test pieces, types M and N, were used in several of the Series XIX to XLIII. These two types appear to be satisfactory substitutes for the standard square test piece, type A. The square test pieces, types P and Q, were used in several of the series of tests from Series XXV to XLIII in order to determine the effect of the increased radius at the root of the notch. All the above-mentioned test pieces were used for tests in the Izod pendulum machine.

The square Charpy test pieces, types S, U and V, have notches corresponding to those on the square Izod test pieces, types A, P and Q respectively. Test pieces types S, U and V were used in several series of experiments from Series XXXI to XLIII.

Most of the material employed in these experiments was tested in the heat-treated condition, but occasionally a series of tests has been put through on an untreated bright drawn mild steel bar, as this material usually gives a low result on the notched bar test, and it was necessary to ensure that the type of test piece adopted was capable of detecting steels in such conditions.



CHARPY PENDULUM MACHINE WITH PENDULUM READY FOR RAISING.
POSITION OF TEST PIECE INDICATED BY X

The analysis of each bar of material used in Series XVII to XLIII is given in Table 2. It will be seen that the majority of the bars used were of nickel or nickel chrome steel.

The heat-treatment given to the steel is shown in Table 3 for all cases in which the particulars are available. In a number of cases the bars used in the experiments were nickel chrome or carbon steel bars taken from stock which had been heat-treated by the suppliers before delivery. In such cases the actual heat-treatment which has been given to the bar is not known with certainty, so that it has been impossible to give informa-

TABLE 2—ANALYSES OF TEST BARS

Material	PERCENTAGES						
	Carbon	Silicon	Sulphur	Phosphorus	Manganese	Nickel	Chromium
Series XVII Bars SS1 and SS2	0.28	0.17	0.019	0.024	0.49	3.90	1.16
Series XVIII Bars SH1 and SH2	0.38	0.22	0.020	0.017	0.42	4.04	2.10
Series XIX Bar A	0.27	0.18	0.025	0.036	0.63	5.00	0.03
Series XX Bar E	0.33	0.20	0.026	0.039	0.47	1.74	0.86
Series XXI Bar C	0.20	0.20	0.054	0.054	0.77	....	....
Series XXII Bar D	0.24	0.11	0.027	0.018	0.82	....	....
Series XXIII Bars SS3 and SS4	0.28	0.17	0.019	0.024	0.49	3.90	1.16
Series XXIV Bars SH3 and SH4	0.38	0.22	0.020	0.017	0.42	4.04	2.10
Series XXV Bar G	0.20	0.20	0.054	0.054	0.76	....	....
Series XXVI Bar B	0.28	0.19	0.027	0.035	0.63	4.96	0.04
Series XXVII Bar F	0.35	0.19	0.028	0.041	0.47	1.76	0.85
Series XXVIII Bar H	0.24	0.11	0.027	0.018	0.82	....	....
Series XXIX Bars SS5 and SS6	0.28	0.17	0.019	0.024	0.49	3.90	1.16
Series XXX Bars SH5 and SH6	0.38	0.22	0.020	0.017	0.42	4.04	2.10
Series XXXI Bar CN	0.38	0.34	0.017	0.017	0.29	2.77	0.87
Series XXXII Bars X1 and X2	0.33	0.46	0.020	0.016	0.63	3.88	1.40
Series XXXIII Bars 1, 2 and 3	0.33	0.46	0.020	0.016	0.63	3.88	1.40
Series XXXIV Bars 4, 5 and 6	0.33	0.46	0.020	0.016	0.63	3.88	1.40
Series XXXV Bars 7, 8 and 9	0.33	0.46	0.020	0.016	0.63	3.88	1.40
Series XXXVI Bar 38	0.24	0.20	0.060	0.044	0.81	0.00	Trace
Series XXXVII Bar 48	0.24	0.20	0.060	0.044	0.81	0.09	Trace
Series XXXVIII Bar 3B	0.37	0.18	0.039	0.043	0.77	3.29	1.07
Series XXXIX Bar 4B	0.34	0.17	0.040	0.038	0.69	2.69	0.98
Series XL Bar 3V	0.41	0.32	0.020	0.017	0.46	3.64	0.67
Series XLI Bar 4V	0.30	0.12	0.032	0.027	0.47	3.28	0.61
Series XLII Bar 3J	0.33	0.34	0.041	0.032	0.47	3.54	1.84
Series XLIII Bar 4J	0.33	0.34	0.041	0.032	0.47	3.54	1.84

tion in this table showing the condition of the material under test. In such cases the material is referred to in the tables as "commercially" heat-treated. In the majority of cases it can be assumed that the heat-treatment had been satisfactorily carried out, as the tests show good values both in the notched bar and the tensile tests.

A large proportion of the material dealt with has been heat-treated specially for these investigations. In many cases the heat-treatment was intentionally incorrect with the object of obtaining low values from the notched bar tests, or determining whether a definite connection could be shown to exist between the notched bar test value and the microstructure. In such cases a piece cut from

TABLE 3—PARTICULARS OF HEAT TREATMENTS

Material	Hardening	Tempering
Series XVII Nickel Chrome Steel, Bar SS1, 2 in. dia.	Heated to 800 deg. C., quenched in oil.	Heated to 635 deg. C., quenched in oil.
Nickel Chrome Steel, Bar SS2, 2 in. dia.	Heated to 1,000 deg. C., quenched in oil.	Heated to 635 deg. C., cooled slowly in furnace.
Series XVIII Nickel Chrome Steel Bar SH1, 2 in. dia.	Heated to 800 deg. C., quenched in oil.	Heated to 635 deg. C., quenched in oil.
Nickel Chrome Steel, Bar SH2, 2 in. dia.	Heated to 1,000 deg. C., quenched in oil.	Heated to 635 deg. C., cooled slowly in furnace.
Series XIX, XX and XXI Bars A, E and C Commercially treated.	Not known.	Not known.
Series XXII Bright Drawn Mild Steel, Bar D	Untreated.	
Series XXIII Nickel Chrome Steel, Bar SS3, 2 in. dia.	Heated to 800 deg. C., quenched in oil.	Heated to 635 deg. C., quenched in oil.
Nickel Chrome Steel, Bar SS4, 2 in. dia.	Heated to 1,000 deg. C., quenched in oil.	Heated to 635 deg. C., cooled slowly in furnace.
Series XXIV Nickel Chrome Steel, Bar SH3, 2 in. dia.	Heated to 800 deg. C., quenched in oil.	Heated to 635 deg. C., quenched in oil.
Nickel Chrome Steel, Bar SH4, 2 in. dia.	Heated to 1,000 deg. C., quenched in oil.	Heated to 635 deg. C., cooled slowly in furnace.
Series XXV, XXVI and XXVII Bars G, F and B Commercially treated.	Not known.	Not known.
Series XXVIII Bright Drawn Mild Steel, Bar H	Untreated.	
Series XXIX Nickel Chrome Steel, Bar SS5, 2 in. dia.	Heated to 800 deg. C., quenched in oil.	Heated to 635 deg. C., quenched in oil.
Nickel Chrome Steel, Bar SS6, 2 in. dia.	Heated to 1,000 deg. C., quenched in oil.	Heated to 635 deg. C., cooled slowly in furnace.
Series XXX Nickel Chrome Steel, Bar SH5, 2 in. dia.	Heated to 800 deg. C., quenched in oil.	Heated to 635 deg. C., quenched in oil.
Nickel Chrome Steel, Bar SH6, 2 in. dia.	Heated to 1,000 deg. C., quenched in oil.	Heated to 635 deg. C., cooled slowly in furnace.
Series XXXI Nickel Chrome Steel, Bar CN, 2 in. dia. Commercially treated.	Not known.	Not known.
Series XXXII Nickel Chrome Steel, Bar X1, 2 in. dia.	Heated to 820 deg. C., air hardened.	Heated to 600 deg. C., quenched in water.
Nickel Chrome Steel, Bar X2, 2 in. dia.	Heated to 820 deg. C., air hardened.	Heated to 600 deg. C., cooled in furnace.
Series XXXIII Nickel Chrome Steel, Bar 1, 2 in. dia.	Heated to 820 deg. C., air hardened.	Heated to 600 deg. C., quenched in water.
Nickel Chrome Steel, Bar 2, 2 in. dia.	Heated to 820 deg. C., air hardened.	Heated to 600 deg. C., cooled in furnace.
Nickel Chrome Steel, Bar 3, 2 in. dia.	(1) Heated to 820 deg. C., air hardened. (2) Heated to 820 deg. C., air hardened. (3) Heated to 820 deg. C., air hardened.	(2) Heated to 600 deg. C., cooled in furnace. (4) Heated to 600 deg. C., quenched in water.
Nickel Chrome Steel, Bar 4, 2 in. dia.	(1) Heated to 1,050 deg. C., air hardened. (2) Heated to 820 deg. C., air hardened.	(3) Heated to 620 deg. C., cooled in furnace. (4) Heated to 600 deg. C., quenched in water.
Nickel Chrome Steel, Bar 5, 2 in. dia.	(1) Heated to 1,050 deg. C., air hardened. (2) Heated to 820 deg. C., air hardened.	(3) Heated to 620 deg. C., quenched in water. (4) Heated to 600 deg. C., quenched in water.
Nickel Chrome Steel, Bar 6, 2 in. dia.	(1) Heated to 1,050 deg. C., air hardened.	(2) Heated to 620 deg. C., quenched in water. (3) Heated to 620 deg. C., cooled more slowly than Bar 8.
Nickel Chrome Steel, Bar 7, 2 in. dia.	Heated to 820 deg. C., air hardened.	Heated to 620 deg. C., quenched in water.
Nickel Chrome Steel, Bar 8, 2 in. dia.	Heated to 1,000 deg. C., air hardened.	Heated to 620 deg. C., cooled slowly.
Nickel Chrome Steel, Bar 9, 2 in. dia.	Heated to 1,050 deg. C., air hardened.	Heated to 620 deg. C., cooled more slowly than Bar 8.
Series XXXVI Carbon Steel, Bar 3S, 2 in. dia. Commercially treated.	Heated to 850 deg. C., quenched in water.	Heated to 720 deg. C., quenched in water.
Series XXXVII Carbon Steel, Bar 4S, 2 in. dia. Commercially treated.	Heated to 850 deg. C., quenched in water.	Heated to 720 deg. C., quenched in water.
Series XXXVIII Nickel Chrome Steel, Bar 3B, 2 in. dia. Commercially treated.	Heated to 810 deg. C., cooled in air.	Heated to 620 deg. C., quenched in water.

SOME EXPERIMENTS ON NOTCHED BARS

TABLE 3—PARTICULARS OF HEAT TREATMENTS

Material	Hardening	Tempering
Series XXXIX Nickel Chrome Steel, Bar 4B, $\frac{1}{2}$ in. dia. Commercially treated.	Heated to 810 deg. C., cooled in air.	Heated to 620 deg. C., quenched in water.
Series XL Nickel Chrome Steel, Bar 3V, $\frac{1}{2}$ in. dia. Commercially treated.	Heated to 815 deg. C., quenched in water.	Heated to 590 deg. C., quenched in water.
Series XLI Nickel Chrome Steel, Bar 4V, $\frac{1}{2}$ in. dia. Commercially treated.	Heated to 815 deg. C., quenched in water.	Heated to 590 deg. C., quenched in water.
Series XLII Nickel Chrome Steel, Bar 3J, $\frac{1}{2}$ in. dia.	Heated to 800 deg. C., air hardened.	None.
Series XLIII Nickel Chrome Steel, Bar 4J, $\frac{1}{2}$ in. dia.	Heated to 800 deg. C., air hardened.	None.

the same bar has been correctly heat-treated for the purpose of making an accurate comparison.

NOTCHED BAR TESTS IN PENDULUM MACHINES

The results obtained for all notched bar tests are given in detail in Table 4 for all tests made in Series XVII to XLIII inclusive.

In most of the experiments up to and including Series XXXII, the test pieces, type M, were tested with flats filed upon the upper end. The object of the flat was to protect the knife edge in the pendulum from excessive wear, caused by striking upon a curved surface. The flats were omitted in all tests on specimens of type M in the experiments from Series XXXIII to XLIII. It has been found that they have very little effect upon the test results obtained, and the knife edge in the pendulum does not appear to have suffered from their omission.

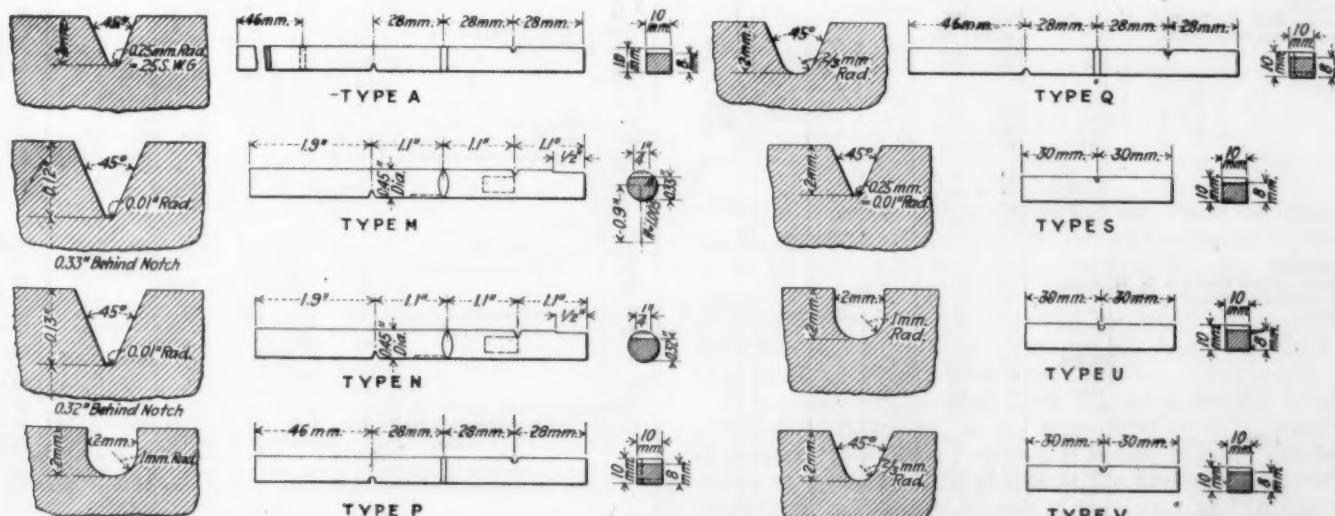
As previously pointed out, the cutting of the notch in the eccentric mandrel proved to be rather a long process, and with a view to eliminating the use of this mandrel, where shaping and milling machines are available for cutting the notches, an alternative test piece, type N, was tried in a number of the experiments from Series XXXIII on. All tests upon the specimens of type N reported in this paper have been made without flats cut upon the upper end of the specimen.

In Table 5, the ninth column gives the average variation from the mean test result expressed in foot-pounds, and the tenth column gives this variation expressed as a percentage of the mean result obtained in each series of tests upon similar test pieces cut from each bar.

The author is of the opinion that too much capital has been made against the notched bar test by concentrating attention on the variations in the test results obtained from certain bars. It will be seen by referring to the table that in some cases the variations in the results of individual tests on the same bar are very small, but that in other cases they are considerable; in many such cases

Series	Heat Treatment (See Table 3)	Type A E_a	Type M E_m	E_m/E_a	Type N E_n	E_n/E_a
XXI	Commercial	82.9	80.5	0.97		
XXIII	Correct	81.7	83.1	1.02		
XXIX	Correct	79.5	83.0	1.04		
XXV	Commercial	79.3	88.9	1.12		
XXXIX	Commercial	75.5	80.7	1.07	81.0	1.07
XX	Commercial	69.9	67.9	0.97		
XXXVIII	Commercial	66.2	69.4	1.05	73.8	1.11
XXIV	Correct	65.8	67.0	1.02		
XXX	Correct	63.5	67.1	1.06		
XXXIII	Correct	63.5	61.2	0.97	63.0	0.99
XXXI	Commercial	60.6	64.7	1.07		
XXXIII	Correct	60.2	61.5	1.02	63.1	1.05
XXVI	Commercial	59.9	59.7	1.00		
XIX	Commercial	57.7	55.7	0.97		
XXXII	Correct	50.6	53.9	1.06		
XLI	Commercial	36.2	39.5	1.09	36.2	1.00
XL	Commercial	30.6	37.0	1.21	31.9	1.04
XXVII	Commercial	24.6	28.5	1.16		
XXXIII	Incorrect	19.2	13.0	0.68	15.1	0.79
XXIX	Incorrect	15.9	14.5	0.91		
XXIII	Incorrect	14.8	10.7	0.72		
XXXII	Incorrect	12.6	8.3	0.66		
XLII	Air hardened	12.4	10.8	0.87	11.8	0.95
XXII	Untreated	12.0	7.8	0.65		
XXIV	Incorrect	11.0	7.3	0.66		
XXX	Incorrect	10.1	10.2	1.01		
XXVIII	Untreated	9.6	10.5	1.10		
XLIII	Air hardened	9.4	8.4	0.89	10.3	1.10

it is quite evident that the bar varied continuously throughout its length. This may be reasonably expected when it is remembered that the control of temperatures in large furnaces is not always what one would desire. Relatively high variations in the values have also been obtained on the bars which have been incorrectly heat-treated deliberately.



THE STANDARD IZOD TEST PIECE AND THE OTHER FORMS WHICH WERE TESTED AND FOUND TO BE SATISFACTORY SUBSTITUTES

TABLE 4—NOTCHED BAR TESTS IN IZOD AND CHARPY PENDULUM MACHINES

Material	Type of Test Piece	Notched Bar Test Results in Foot-Pounds						Mean Results Ft.-lb.	Material	Type of Test Piece	Notched Bar Test Results in Foot-Pounds						Mean Results Ft.-lb.
		78	80	79	83	76.5n	76.5n	..			30y	29y	..	..	..	..
Series XVII									Nickel Chrome Steel, Bar SS1, 2 in. dia., correctly treated.	St. Sq. A*	74n	77n	76.5n	76.5n	..	24.5	
Nickel Chrome Steel, Bar SS1, 2 in. dia., correctly treated.	St. Sq. A*	78	80	79	83	76.5n	76.5n	..	24.5								
Nickel Chrome Steel, Bar SS2, 2 in. dia., incorrectly treated.	St. Sq. A*	11	6	4	6	..	..	..	24.5							
Nickel Chrome Steel, Bar SS2, 2 in. dia., incorrectly treated.	St. Sq. A*	12b	13.5b	6.5b	13.5b	..	..	9.1	24.5							
Series XVIII									Nickel Chrome Steel, Bar SH1, 2 in. dia., correctly treated.	St. Sq. A*	65	65	63	63	..	28.5	
Nickel Chrome Steel, Bar SH1, 2 in. dia., correctly treated.	St. Sq. A*	61y	61y	60y	59y	..	..	62.1	28.5							
Nickel Chrome Steel, Bar SH2, 2 in. dia., incorrectly treated.	St. Sq. A*	7	7	7.5	9	..	..	..	28.5							
Nickel Chrome Steel, Bar SH2, 2 in. dia., incorrectly treated.	St. Sq. A*	9b	8b	8b	8.5b	..	..	8.0	28.5							
Series XIX									Nickel Chrome Steel, Bar A, 1/2 in. dia., heat-treated commercially.	St. Sq. A*	55n	55n	52n	..	..	40.5
Nickel Chrome Steel, Bar A, 1/2 in. dia., heat-treated commercially.	St. Sq. A*	55n	63n	56n	..	..	..	..	40.5							
Nickel Chrome Steel, Bar A, 1/2 in. dia., heat-treated commercially.	St. Sq. A*	58.5n	64n	57.5n	..	..	..	57.7	40.5							
St. Rd.	44n	45y	..	..	..	..	..	..	St. Rd.	33y	33y	34y	..	..	..	..
M†	51n	57y	..	..	..	..	..	..	M†	30y	32y	35y	..	..	..	..
M†	64n	59y	..	..	..	..	..	..	M†	25.5y	26y	29y	..	..	..	..
M†	64n	62y	..	..	..	..	..	..	M†	20y	23y	21y	..	..	..	..
Series XX									Nickel Chrome Steel, Bar E, 1/2 in. dia., heat-treated commercially.	Sq. P†	46y	49y
Nickel Chrome Steel, Bar E, 1/2 in. dia., heat-treated commercially.	St. Sq. A*	74n	61n	70n	Nickel Chrome Steel, Bar E, 1/2 in. dia., heat-treated commercially.	Sq. P†	45y	48.5y
Nickel Chrome Steel, Bar E, 1/2 in. dia., heat-treated commercially.	St. Sq. A*	76n	76.5n	70n	Nickel Chrome Steel, Bar E, 1/2 in. dia., heat-treated commercially.	Sq. P†	36y	38y
Nickel Chrome Steel, Bar E, 1/2 in. dia., heat-treated commercially.	St. Sq. A*	68n	66n	68n	Nickel Chrome Steel, Bar E, 1/2 in. dia., heat-treated commercially.	Sq. P†	28y	34b
St. Rd.	57b	67y	..	..	..	..	..	..	St. Rd.	9y	10y	11y	..	..	..	..
M†	72.5n	66y	..	..	..	..	..	..	M†	9y	9.5y	11y	..	..	..	..
M†	72n	69y	..	..	..	..	..	..	M†	13y	9y	11y	..	..	..	..
M†	67n	73y	..	..	..	..	..	..	Sq. P†	37.5y	70n	..	..	..	..	..
Series XXI									Nickel Chrome Steel, Bar E, 1/2 in. dia., heat-treated commercially.	Sq. P†	35y	48n
Carbon Steel, Bar C, 1/2 in. dia., heat-treated commercially.	St. Sq. A*	87n	80n	85n	Nickel Chrome Steel, Bar E, 1/2 in. dia., heat-treated commercially.	Sq. P†	42n	40n
Carbon Steel, Bar C, 1/2 in. dia., heat-treated commercially.	St. Sq. A*	85n	86n	82n	Nickel Chrome Steel, Bar E, 1/2 in. dia., heat-treated commercially.	Sq. P†	40n	72n
Carbon Steel, Bar C, 1/2 in. dia., heat-treated commercially.	St. Sq. A*	83n	70n	88.5n	..	..	..	..	St. Rd.	89n	87n	..	..	..	..	..
St. Rd.	89n	87n	..	..	..	..	..	..	M†	85n	89n	..	..	..	..	..
M†	75n	53y	..	..	..	..	..	..	M†	75n	..	..	..	..	..	..
M†	83n	83n	..	..	..	..	..	..	M†	83n	..	..	..	..	..	..
St. Rd.	11y	12.5y	12y	..	..	..	..	..	St. Rd.	89n	87n	..	..	..	..	..
A*	12y	12y	11.5y	..	..	..	..	..	M†	85n	89n	..	..	..	..	..
A*	8y	11y	8y	..	..	..	..	..	M†	75n	..	..	..	..	..	..
A*	10y	20.5	15y	..	..	..	..	..	M†	11y	9y	..	..	..	..	..
Series XXII									Nickel Chrome Steel, Bar SH5, 1 1/2 in. dia. untreated.	St. Sq. A*	61.5n	62.0n	65n	65.5n	..	63.5	
Bright drawn Mild Steel, Bar D, 1 1/2 in. dia. untreated.	St. Sq. A*	11y	12.5y	12y	..	..	..	..	Nickel Chrome Steel, Bar SH5, 1 1/2 in. dia. untreated.	St. Rd. M†	68.5n	67.5n	65b	65b	..	67.1
Bright drawn Mild Steel, Bar D, 1 1/2 in. dia. untreated.	St. Sq. A*	12y	12y	11.5y	..	..	..	..	Nickel Chrome Steel, Bar SH6, 2 in. dia. incorrectly treated.	St. Sq. A*	9.5b	10.5b	11.5y	9.0y	..	10.1
Bright drawn Mild Steel, Bar D, 1 1/2 in. dia. untreated.	St. Sq. A*	8y	11y	8y	..	..	..	..	Nickel Chrome Steel, Bar SH6, 2 in. dia. incorrectly treated.	St. Rd. M†	8.5y	9b	10b	13.5b	..	10.2
Bright drawn Mild Steel, Bar D, 1 1/2 in. dia. untreated.	St. Sq. A*	10y	20.5	15y	..	..	..	..	St. Rd. A*	61.5n	62.0n	65n	65.5n	..	63.5	
St. Rd.	8y	7y	..	..	..	..	..	..	St. Rd. M†	68.5n	67.5n	65b	65b	..	63.0	
M†	5y	7y	..	..	..	..	..	..	St. Rd. M†	65.5n	65.5y	63n	..	..	64.7	
M†	8y	7.5y	..	..	..	..	..	..	Sq. P†	82n	80.5n	78n	74n	..	76.7	
M†	11y	9y	..	..	..	..	..	..	Sq. R†	77n	70n	78n	74n	..	76.7	
St. Rd.	8y	7y	..	..	..	..	..	..	Sq. R†	33.1	34.7	33.9	33.1	..	33.7	
M†	5y	7y	..	..	..	..	..	..	Sq. S†	62.8	62.8	60.9	62.8	..	62.3	
M†	8y	7.5y	..	..	..	..	..	..	Sq. U†	80	76	74	72	..	75.5	
M†	11y	9y	..	..	..	..	..	..	St. Sq. A*	77.5n	77.5n	80.0n	83.0n	..	80.5	
Series XXIII									Nickel Chrome Steel, Bar SS3, 2 in. dia. correctly treated.	St. Sq. A*	83.5n	81.0b	85.0n	82.5n	..	83.0	
Nickel Chrome Steel, Bar SS3, 2 in. dia. correctly treated.	St. Sq. A*	79.5n	82.5n	83.0n	..	..	..	..	Nickel Chrome Steel, Bar SS3, 2 in. dia. correctly treated.	St. Rd. M†	12.5b	14.5b	16b	14.5b	..	14.5
Nickel Chrome Steel, Bar SS3, 2 in. dia. correctly treated.	St. Rd.	80.5y	85.5y	87.0y	82.0n	..	..	..	Nickel Chrome Steel, Bar SS3, 2 in. dia. correctly treated.	St. Sq. A*	18.0y	15b	16b	14.5b	..	15.9
Nickel Chrome Steel, Bar SS3, 2 in. dia. correctly treated.	St. Rd.	80.5y	83.5y	82.5y	83.5y	..	..	..	Nickel Chrome Steel, Bar SS3, 2 in. dia. correctly treated.	St. Rd. M†	12.5b	14.5b	16b	14.5b	..	14.5
Nickel Chrome Steel, Bar SS4, 2 in. dia. incorrectly treated.	St. Sq. A*	17.0b	14.5b	13.0b	..	..	..	..	St. Sq. A*	61.5n	62.0n	65n	65.5n	..	63.5	
Nickel Chrome Steel, Bar SS4, 2 in. dia. incorrectly treated.	St. Rd.	14.0b	14.0b	8.5b	6.5b	..	..	..	St. Rd. M†	68.5n	67.5n	65b	65b	..	67.1	
Nickel Chrome Steel, Bar SS4, 2 in. dia. incorrectly treated.	M†	12.0b	13.5b	9.0b	8.0b	..	..	..	St. Sq. A*	9.5b	10.5b	11.5y	9.0y	..	10.1	
Nickel Chrome Steel, Bar SH3, 2 in. dia., correctly treated.	St. Sq. A*	65.5y	65.5y	66.5y	..	..	..	..	St. Rd. M†	8.5y	9b	10b	13.5b	..	10.2	
Nickel Chrome Steel, Bar SH3, 2 in. dia., correctly treated.	St. Rd.	65.5y	66.5y	66.0y	68.5y	..	..	..	St. Sq. A*	21	20.5	18.5	17	..	19.25	
Nickel Chrome Steel, Bar SH4, 2 in. dia., incorrectly treated.	St. Sq. A*	10.0b	12.0b	11.0b	..	..	..	..	St. Rd. M†	16b	13.5b	12b	10b	..	13.0	
Nickel Chrome Steel, Bar SH4, 2 in. dia., incorrectly treated.	St. Rd.	5.0b	6.5b	7.5b	7.0b	..	..	..	St. Rd. N†	17b	15b	13b	15b	..	15.1	
Nickel Chrome Steel, Bar SH4, 2 in. dia., incorrectly treated.	M†	7.5b	8.5b	6.5b	10.0b	..	..	..	Sq. P†	39.5b	31.5b	27b	27.5b	..	31.4	
Series XXIV									Sq. S†	17.6b	15.0b	13.7b	..	..	15.4	
Nickel Chrome Steel, Bar SH3, 2 in. dia., correctly treated.	St. Sq. A*	65.5y	65.5y	66.5y	..	..	..	..	Sq. U†	32.2b	27.6b	26.0b	..	..	28.6	
Nickel Chrome Steel, Bar SH3, 2 in. dia., correctly treated.	St. Rd.	65.5y	66.5y	68.0y	68.5y	..	..	..	St. Sq. A*	61	61	59	60	..	60.2	
Nickel Chrome Steel, Bar SH4, 2 in. dia., incorrectly treated.	St. Sq. A*	10.0b	12.0b	11.0b	..	..	..	..	St. Rd. M†	61.5b	63b	62y	61y	..	61.5	
Nickel Chrome Steel, Bar SH4, 2 in. dia., incorrectly treated.	St. Rd.	5.0b	6.5b	7.5b	7.0b	..	..	..	St. Rd. N†	62y	65y	63.5y	63y	..	63.1	
Nickel Chrome Steel, Bar SH4, 2 in. dia., incorrectly treated.	M†	7.5b	8.5b	6.5b	10.0b	..	..	..	Sq. P†	79.5y	72.5y	74.5y	67.5y	..	71.2	
Nickel Chrome Steel, Bar SH4, 2 in. dia., incorrectly treated.	M†	82.5n	93n	96.5n	..	..	..	..	Sq. S†	59.7b	63.5b	59.7b	..	..	61.0	
Nickel Chrome Steel, Bar SH4, 2 in. dia., incorrectly treated.	M†	82.5n	93n	96.5n	..	..	..	..	Sq. U†	65.3b	74.9b	72.9b	..	..	71.0	
Series XXV									St. Sq. A*	49y	50y	54y	43y	..	50.5		
Carbon Steel Bar G, 1/2 in. dia. heat-treated commercially.	St. Sq. A*	86n	72n	..	..	..	..	St. Sq. A*	66	64	64	64	..	63.5		
Carbon Steel Bar G, 1/2 in. dia. heat-treated commercially.	A*	81.5n	88n	..	..										

SOME EXPERIMENTS ON NOTCHED BARS

TABLE 4—NOTCHED BAR TESTS IN IZOD AND CHARPY PENDULUM MACHINES

Material	Type of Test Piece	Notched Bar	Test Results in Foot-Pounds	Mean Results
Series XXXV				
Nickel Chrome Steel, Bar 7, 2 in. dia., correctly treated.	St.Sq.A*	56.5y	59.5y	60.5y
	Sq.Q†	71.5n	57.5n	65.5n
	Sq.S†	69b	65b	63.5b
	Sq.S†	..	..	63.1b
	Sq.V†	76b	73b	71b
	Sq.V†	..	..	72.7
Nickel Chrome Steel, Bar 8, 2 in. dia. For heat-treatment see Table 3.	St.Sq.A*	53.5y	56y	58y
	Sq.Q†	60y	63y	62.5y
	Sq.S†	53.0b	..	51.2b
	Sq.S†	..	..	51.2b
	Sq.V†	55.6b	..	54.5b
	Sq.V†	..	..	57.6b
Nickel Chrome Steel, Bar 9, 2 in. dia. For heat-treatment see Table 3.	St.Sq.A*	36y	33y	30y
	Sq.Q†	47y	42y	43.5y
	Sq.S†	26.9b	..	31.6b
	Sq.S†	..	..	30.0
	Sq.V†	39.6b	..	39.6b
	Sq.V†	..	..	36.3
				34.7
				37.6
Series XXXVI				
Carbon Steel, Bar 3S, $\frac{3}{4}$ in. dia., heat-treated commercially.	Sq.S†	140.7n	140.7n	141.5n
	Sq.U†	141.5n	171.2n	149n
				141
				153.9
Series XXXVII				
Carbon Steel, Bar 4S, $\frac{1}{2}$ in. dia., heat-treated commercially.	Sq.S†	164.5n	175.1n	139.7n
	Sq.U†	174.3n	171.2n	145n
				159.8
				163.5
Series XXXVIII				
Nickel Chrome Steel, Bar 3B, $\frac{5}{8}$ in. dia., heat-treated commercially.	St.Sq.A*	59n	56n	64n
	St.Sq.A*	71n	71n	76n
	St.Rd.M†	63y	68.5y	68y
	St.Rd.M†	68n	73n	76n
	St.Rd.N†	70y	67y	69y
	St.Rd.N†	80n	80n	77n
	Sq.P†	67a	69.5n	74n
	Sq.P†	72n	77n	70n
	Sq.S†	59.9b	68.8b	62.1b
	Sq.U†	90.4y	78.5y	74.6y
				81.2
Series XXXIX				
Nickel Chrome Steel, Bar 4B, $\frac{1}{2}$ in. dia., heat-treated commercially.	St.Sq.A*	74n	82n	70n
	St.Sq.A*	74n	76n	77n
	St.Rd.M†	81n	80.5n	80n
	St.Rd.M†	76n	83.5n	83n
	St.Rd.N†	81.5n	78n	77n
	St.Rd.N†	83.5n	81.5n	84.5n
	Sq.P†	81n	80n	82n
	Sq.P†	79n	78n	84n
	Sq.S†	88.5y	92.3y	92.8y
	Sq.U†	102.2y	90.4y	94.8y
				95.8
Series XL				
Nickel Chrome Steel, Bar 3V, $\frac{5}{8}$ in. dia., heat-treated commercially.	St.Sq.A*	30y	30y	30y
	St.Sq.A*	31y	31.5y	31y
	St.Rd.M†	36.5y	37y	33y
	St.Rd.M†	37.5y	38y	40y
	St.Rd.N†	32y	31.5y	31y
	St.Rd.N†	30.5y	33y	33.5y
	Sq.Q†	30y	30y	31.5y
	Sq.Q†	33y	33y	34.5b
	Sq.S†	25.8b	26.5b	27.6b
	Sq.V†	29.6b	30.3b	32.7b
				30.9
Series XLI				
Nickel Chrome Steel, Bar 4V, $\frac{5}{8}$ in. dia., heat-treated commercially.	St.Sq.A*	34.5y	33y	33y
	St.Sq.A*	38y	38y	40.5y
	St.Rd.M†	35y	34b	37y
	St.Rd.M†	42y	45y	44y
	St.Rd.N†	32y	33.5y	35y
	St.Rd.N†	39y	36y	41.5y
	Sq.Q†	36.5y	35y	37.5y
	Sq.Q†	45.5y	44y	44.5y
	Sq.S†	27.3b	26.1b	30.3b
	Sq.V†	33.4b	31.1b	36.7b
				33.7
Series XLII				
Nickel Chrome Steel, Bar 3J, 1 in. dia., air hardened.	St.Sq.A*	12.5b	14b	10b
	St.Sq.A*	13.5b	11b	13.5b
	St.Rd.M†	13.5b	11b	11b
	St.Rd.M†	8.5b	8.5b	12b
	St.Rd.N†	9b	11b	12b
	St.Rd.N†	13b	13.5b	12.5b
	Sq.Q†	17.5b	18.5b	18b
	Sq.Q†	20b	20b	21b
	Sq.S†	12.2b	12.8b	9.5b
	Sq.V†	18.7b	21.0b	..
				11.5
				19.9
Series XLIII				
Nickel Chrome Steel, Bar 4J, 1 in. dia., air hardened.	St.Sq.A*	8.5b	11b	11b
	St.Sq.A*	10b	7b	9b
	St.Rd.M†	7.5b	8b	9b
	St.Rd.M†	8.5b	9b	8.5b
	St.Rd.N†	7b	8b	8b
	St.Rd.N†	12b	13.5b	13.5b
	Sq.Q†	11b	11b	13.5b
	Sq.Q†	18b	18b	17.9b
	Sq.S†	9.5b	9.8b	8.6b
	Sq.V†	19.3b	16.6b	17.9b
				17.9

NOTES.—The letters in italics in the third to seventh columns have been used to indicate the condition of the test piece after completion of the notched bar test in the pendulum machine:

a—entirely broken through

b—fracture nearly complete—i.e. upper part of test piece could be easily pulled off by hand

c—not broken—i.e. the test piece required considerable force to complete the fracture

*standard square test pieces, Type A

†standard round test pieces, Types M and N

‡square test pieces

All tests carried out on Izod machine except those marked *¶*

Tests marked thus *¶* carried out on Charpy machine

COMPARISSON OF TEST RESULTS

For convenience in making a comparison of results obtained from round test pieces, types M and N, with the results obtained from standard square test pieces, type A the ratios of the mean results, E_m/E_a and E_n/E_a , are given in the small table on page 351. The table has been arranged in descending order of the mean test results, E_a , obtained from the standard square test piece, type A. It will be seen from this table that the ratio of mean results approximates unity in most of the tests.

Series	Heat Treatment (See Table 3)	E_a Average Izod	E_a Average Charpy	E_a/E_a
XXXIX	Commercial	Ft.-lb. A75.5	Ft.-lb. S91.2	1.21
XXXVIII	Commercial	66.2	63.6	0.96
XXXIII	Correct	63.5	57.3	0.90
XXXI	Commercial	60.6	62.3	1.03
XXXII	Correct	60.2	61.0	1.01
XXXV	Correct	58.3	65.1	1.12
XXXV	Special	56.4	52.7	0.94
XXXIV	Special	56.2	56.6	1.01
XXXIV	Correct	54.4	59.4	1.09
XXXII	Correct	50.6	54.4	1.07
XLI	Commercial	36.2	27.9	0.77
XXXV	Special	32.1	28.5	0.89
XL	Commercial	30.6	26.6	0.87
XXXIII	Incorrect	19.2	15.4	0.80
XXXII	Incorrect	12.6	12.9	1.02
XLI	Air hardened	12.4	11.5	0.93
XXXIV	Incorrect	10.9	13.2	1.21
XLI	Air hardened	9.4	9.3	0.99

Series	Heat Treatment (See Table 3)	E_a Average Izod	E_a Average Charpy	E_a/E_a
XXXX	Correct	Ft.-lb. Q65.1	Ft.-lb. V72.7	1.12
XXXXIV	Special	64.2	62.7	0.98
XXXXIV	Correct	63.3	68.4	1.08
XXXXV	Special	62.1	59.4	0.96
XXXXV	Special	43.1	37.6	0.87
XLI	Commercial	40.5	33.7	0.83
XL	Commercial	32.0	30.9	0.97
XLI	Air hardened	19.2	19.9	1.04
XXXIV	Incorrect	18.1	20.2	1.12
XLI	Air hardened	14.9	17.9	1.20

Series	Heat Treatment (See Table 3)	E_a Average Izod	E_a Average Charpy	E_a/E_a
XXXIX	Commercial	Ft.-lb. P80.7	Ft.-lb. U95.8	1.10
XXXI	Commercial	76.7	75.5	0.98
XXXVIII	Commercial	71.6	81.2	1.13
XXXIII	Special	71.2	71.0	1.00
XXXIII	Correct	68.5	69.1	1.01
XXXII	Correct	63.1	63.1	1.00
XXXIII	Incorrect	31.4	28.6	0.91
XXXII	Incorrect	29.6	27.7	0.94

For round test pieces, type M, the ratio of results E_m/E_a obtained from correctly treated specimens is found to be between 0.87 and 1.21, and the average value of the ratio is equal to 1.03. For steels which had been incorrectly treated intentionally, or which were in the untreated condition, the ratio ranges from 0.65 to 1.10 with an average value of 0.79.

For round test pieces, type N, the correctly treated steels give values of E_n/E_a from 0.95 to 1.11, with an average ratio of 1.04. Only one series of tests has been made on a steel which had been incorrectly heat-treated intentionally, using this type of specimen, and this series gave a ratio of mean results of 0.79.

The number of individual tests made in each series

was insufficient to eliminate the effect of the variations in the material along the length of the bar, and it should be noted, in considering the individual ratios given in the table on page 351, that it would be quite reasonable to assume that where the ratios E_m/E_a and E_n/E_a are above the average, the variations in the material will probably have favored the round test piece rather than the square, and that where the ratio is below the average the variations have favored the square test piece.

It appears from the results obtained that either of the round test pieces, types M or N, should prove satisfactory for acceptance tests on steels.

Parallel tests on test pieces with similar notches were made in the Charpy and Izod machines. It will be convenient first to consider the effect of the machine, and in this connection the mean results obtained from test pieces, types S, V and U, tested in the Charpy machine, compared with those obtained from the similar square test pieces, types A, P and Q and the ratios E_s/E_a , E_v/E_a , and E_u/E_a , have been collected in tabular form on page 353 for convenient reference. It will be seen that for values higher than 70 ft.-lb. obtained in the Izod machine, there is a tendency for the Charpy machine to give somewhat higher values than those obtained from the Izod. This is explained by the fact that for steels in the conditions which give high values, the test pieces are not usually completely broken and they are bent through a larger angle in the Charpy machine than in the Izod.

For test pieces type A and type S it will be seen that the ratio of mean results E_s/E_a lies between extreme values of 0.77 and 1.21 with an average ratio equal to 0.99; for test pieces type Q and type V the ratio E_v/E_a lies between values 0.83 and 1.20 with an average ratio of 1.017, and for test pieces type P and type U the ratio E_u/E_a lies between 0.91 and 1.19 with an average ratio of 1.020.

Considering the whole of the thirty-six series of tests referred to in the three tables above, the average value of the ratios of the mean result obtained from the Charpy to the mean result obtained from the Izod tests is 1.004. These results show that the machine has very little influence, if any, on the value obtained from the notched bar test, and confirm a large number of tests which have been made in previous experiments by other investigators.

In view of the conclusion arrived at above, the test results on specimens types Q and V, together with those obtained from the standard square test piece in the Izod machine, are given in the accompanying tables:

Series	Heat Treatment (See Table 3)	Type A E_a	Type Q E_q	E_q/E_a	Type V E_v	E_v/E_a
XXXV	Correct	Ft.-lb.	Ft.-lb.		Ft.-lb.	
XXXV	Correct	58.3	65.1	1.12	72.7	1.25
XXXV	Special	56.4	62.1	1.10	59.4	1.05
XXXIV	Special	56.2	64.2	1.14	62.7	1.12
XXXIV	Special	54.4	63.3	1.16	68.4	1.26
XLI	Commercial	36.2	40.5	1.12	33.7	0.93
XXXV	Incorrect	32.1	43.1	1.34	37.6	1.17
XL	Commercial	30.6	32.0	1.05	30.9	1.01
XLII	Air hardened	12.4	19.2	1.55	19.9	1.60
XLII	Incorrect	10.9	18.1	1.66	20.2	1.85
XLII	Air hardened	9.4	14.9	1.58	17.9	1.90

It will be seen from the list that while the values obtained from test pieces, types Q and V, are very similar to those obtained from the standard square test pieces type A for steels correctly treated, this is no longer the case when the results obtained from steels incorrectly treated, or in the untreated condition, are considered.

This point is even more strongly brought out in the table showing the comparison of results obtained from test pieces types P and U, with those obtained on the standard test piece, type A. In particular it is found that on an untreated bright drawn steel, Series XXVIII, the test pieces type P have given a mean result 5.03 times the mean result obtained from the standard test pieces type A.

Series	Heat Treatment (See Table 3)	Type A E_a	Type P E_p	E_p/E_a	Type U E_u	E_u/E_a
XXV	Commercial	Ft.-lb.	Ft.-lb.	1.10		
XXXIX	Commercial	75.5	80.7	1.07	95.8	1.27
XXXVIII	Commercial	66.2	71.6	1.08	81.2	1.23
XXXIII	Correct	63.5	68.5	1.08	69.1	1.09
XXXI	Commercial	60.6	76.7	1.26	75.5	1.24
XXXIII	Correct	60.2	71.2	1.18	71.0	1.18
XXVI	Commercial	59.9	68.4	1.14		
XXXII	Correct	50.6	63.1	1.25	63.1	1.25
XXVII	Commercial	24.6	40.6	1.65		
XXXIII	Incorrect	19.2	31.4	1.63	28.6	1.49
XXXIII	Incorrect	12.6	29.6	2.35	27.7	2.20
XXVIII	Untreated	9.6	48.1	5.03		

It appears to the author that the following conclusions can be fairly drawn from these tests and comparisons:

1 That so long as the steel is in a correctly treated condition the influence of the shape at the base of the notch is relatively small.

2 That for the detection of a steel which has been incorrectly heat-treated the influence of the shape at the base of the notch is considerable.

Hence the author is of the opinion that for acceptance tests it is inadvisable to adopt a type of test piece in which the root of the notch is rounded to any considerable radius, and it is suggested that the rule for the cutting of the notch in the standard test piece, type A, should be that the radius at the root of the notch shall be *not more than 0.25 mm. or 0.01 in.*, and that the notch should be regarded as satisfactorily cut if this radius is not exceeded.

TENSILE TESTS

The results obtained from the tensile tests of all bars dealt with in Series XVII to XLIII are given in Table 1, and the average result obtained from the corresponding standard square Izod test pieces, type A, have been added in the last column of the table for convenience in comparing results.

The results show that with different treatments it is possible to obtain practically identical tensile test results—such as limit of proportionality, yield point, ultimate stress, elongation and reduction of area—with very different notched bar test results from the same piece of steel. It is therefore clear that the tensile test, even though it is made carefully, using an extensometer, offers no criterion which can be trusted, for discovering when a material is in the condition which gives low notched bar test results.

This statement must not be taken to mean that with correct heat-treatments there is no connection between the tensile test results and those obtained from the notched bar tests. If a steel bar of a given composition is satisfactorily hardened, and is then correctly tempered at a given temperature, it should give results in the notched bar tests, and for each property of the tensile test, such that each value is within a fairly narrow range corresponding with the tempering temperature.

For a nickel chrome steel slow cooling from the tem-

SOME EXPERIMENTS ON NOTCHED BARS

TABLE 5—COMPARISON OF TEST RESULTS ON ROUND AND SQUARE TEST PIECES

Material	Type of Test Piece	DIMENSIONS OF TEST PIECES				RESULTS OF TESTS					Material	Type of Test Piece	DIMENSIONS OF TEST PIECES				RESULTS OF TESTS				
		Size of Test Piece	Thickness at Groove or Notch	Angle of Groove or Notch	Radius at Root	Number of Test	Mean Energy Absorbed	Average Variation from Mean	Percentage Variation from Mean	Ratio of Mean Results to Mean Results on Standard Square Test Piece			Size of Test Piece	Thickness at Groove or Notch	Angle of Groove or Notch	Radius at Root	Number of Test	Mean Energy Absorbed	Average Variation from Mean	Percentage Variation from Mean	Ratio of Mean Results to Mean Results on Standard Square Test Piece
Series XVII Nickel Chrome Steel, Bar SS1, 2 in. dia., correctly treated.	A*	10 mm.	8 mm.	45	0.25 mm.	8	78.0	2.0	2.6	...	Series XXIX Nickel Chrome Steel, Bar SS5, 2 in. dia., correctly treated.	A*	10 mm.	8 mm.	45	0.25 mm.	4	79.5	2.0	2.8	...
Nickel Chrome Steel, Bar SS2, 2 in. dia., incorrectly treated.	A*	10 mm.	8 mm.	45	0.25 mm.	8	9.1	3.5	38.4	...	Nickel Chrome Steel, Bar SS5, 2 in. dia., incorrectly treated.	M†	0.45 in. dia.	0.33 in.	45	0.01 in.	4	83.0	1.2	1.5	1.04
Series XVIII Nickel Chrome Steel, Bar SH1, 2 in. dia., correctly treated.	A*	10 mm.	8 mm.	45	0.25 mm.	8	62.1	1.9	3.0	...	Series XXX Nickel Chrome Steel, Bar SH5, 2 in. dia., correctly treated.	A*	10 mm.	8 mm.	45	0.25 mm.	4	63.5	1.7	2.8	...
Nickel Chrome Steel, Bar SH2, 2 in. dia., incorrectly treated.	A*	10 mm.	8 mm.	45	0.25 mm.	8	8.0	0.6	7.8	...	Nickel Chrome Steel, Bar SH6, 2 in. dia., incorrectly treated.	M†	0.45 in. dia.	0.33 in.	45	0.01 in.	4	67.1	1.1	1.6	1.06
Series XIX Nickel Chrome Steel, Bar A, 1 in. dia., heat-treated commercially.	A*	10 mm.	8 mm.	45	0.25 mm.	9	57.7	2.9	5.0	...	Series XXXI Nickel Chrome Steel, Bar CN, 2 in. dia., heat-treated commercially.	A*	10 mm.	8 mm.	45	0.25 mm.	8	60.6	1.5	2.5	...
M†	0.45 in. dia.	0.33 in.	45	0.01 in.	8	55.7	6.8	12.2	0.97	Nickel Chrome Steel, Bar CN, 2 in. dia., heat-treated commercially.	M†	0.45 in. dia.	0.33 in.	45	0.01 in.	3	64.7	1.1	1.7	1.07	
Series XX Nickel Chrome Steel, Bar E, 1 in. dia., heat-treated commercially.	A*	10 mm.	8 mm.	45	0.25 mm.	9	69.9	3.7	5.3	...	Nickel Chrome Steel, Bar CN, 2 in. dia., heat-treated commercially.	P†	10 mm.	8 mm.	0	1.0 mm.	8	76.7	3.0	3.9	1.26
M†	0.45 in. dia.	0.33 in.	45	0.01 in.	8	67.9	3.7	5.4	0.97	Nickel Chrome Steel, Bar CN, 2 in. dia., heat-treated commercially.	Sq.S†	10 mm.	8 mm.	45	0.25 mm.	4	62.3	0.7	1.1	1.03	
Series XXI Carbon Steel, Bar C, 1 in. dia., heat-treated commercially.	A*	10 mm.	8 mm.	45	0.25 mm.	9	82.9	3.7	4.5	...	Nickel Chrome Steel, Bar CN, 2 in. dia., heat-treated commercially.	Sq.U†	10 mm.	8 mm.	0	1.0 mm.	4	75.5	2.5	3.3	1.24
M†	0.45 in. dia.	0.33 in.	45	0.01 in.	8	80.5	8.2	10.2	0.97	Series XXXII Nickel Chrome Steel, Bar XI, 2 in. dia., correctly treated.	A*	10 mm.	8 mm.	45	0.25 mm.	5	50.6	3.9	7.7	...	
Series XXII Bright drawn Mild Steel, Bar D, 1 in. dia., untreated.	A*	10 mm.	8 mm.	45	0.25 mm.	12	12.0	2.0	17.0	0.65	Nickel Chrome Steel, Bar XI, 2 in. dia., correctly treated.	M†	0.45 in. dia.	0.33 in.	45	0.01 in.	5	53.9	3.0	5.5	1.06
M†	0.45 in. dia.	0.33 in.	45	0.01 in.	8	7.8	1.2	15.2	0.65	Nickel Chrome Steel, Bar XI, 2 in. dia., correctly treated.	P†	10 mm.	8 mm.	0	1.0 mm.	4	63.1	2.6	4.1	1.25	
Series XXIII Nickel Chrome Steel, Bar SS3, 2 in. dia., correctly treated.	A*	10 mm.	8 mm.	45	0.25 mm.	3	81.7	1.4	1.7	1.02	Nickel Chrome Steel, Bar XI, 2 in. dia., correctly treated.	Sq.S†	10 mm.	8 mm.	45	0.25 mm.	3	54.4	4.1	7.5	1.07
M†	0.45 in. dia.	0.33 in.	45	0.01 in.	8	83.1	1.7	2.1	1.02	Nickel Chrome Steel, Bar XI, 2 in. dia., correctly treated.	Sq.U†	10 mm.	8 mm.	0	1.0 mm.	3	63.1	3.7	5.9	1.25	
Nickel Chrome Steel, Bar SS4, 2 in. dia., incorrectly treated.	A*	10 mm.	8 mm.	45	0.25 mm.	3	14.8	1.4	9.7	0.72	Series XXXIII Nickel Chrome Steel, Bar 1, 1 in. dia., correctly treated.	A*	10 mm.	8 mm.	45	0.25 mm.	8	60.6	1.5	2.5	...
M†	0.45 in. dia.	0.33 in.	45	0.01 in.	8	10.7	2.7	25.1	0.72	Nickel Chrome Steel, Bar 1, 1 in. dia., correctly treated.	M†	0.45 in. dia.	0.33 in.	45	0.01 in.	5	53.9	3.0	5.5	1.06	
Series XXIV Nickel Chrome Steel, Bar SH3, 2 in. dia., correctly treated.	A*	10 mm.	8 mm.	45	0.25 mm.	3	65.8	0.4	0.7	...	Nickel Chrome Steel, Bar 1, 1 in. dia., correctly treated.	P†	10 mm.	8 mm.	0	1.0 mm.	4	68.5	2.0	2.9	1.08
M†	0.45 in. dia.	0.33 in.	45	0.01 in.	8	67.0	1.4	2.0	1.02	Nickel Chrome Steel, Bar 1, 1 in. dia., correctly treated.	Sq.S†	10 mm.	8 mm.	45	0.25 mm.	3	57.3	3.2	5.6	0.90	
Nickel Chrome Steel, Bar SH4, 2 in. dia., incorrectly treated.	A*	10 mm.	8 mm.	45	0.25 mm.	3	11.0	0.7	6.1	0.66	Nickel Chrome Steel, Bar 1, 1 in. dia., correctly treated.	Sq.U†	10 mm.	8 mm.	0	1.0 mm.	3	69.1	2.5	3.7	1.09
M†	0.45 in. dia.	0.33 in.	45	0.01 in.	8	7.3	1.1	14.5	0.66	Nickel Chrome Steel, Bar 1, 1 in. dia., correctly treated.	A*	10 mm.	8 mm.	45	0.25 mm.	4	19.2	1.5	7.8	...	
Series XXV Carbon Steel, Bar G, 1 in. dia., heat-treated commercially.	A*	10 mm.	8 mm.	45	0.25 mm.	8	79.3	7.0	8.8	...	Nickel Chrome Steel, Bar 1, 1 in. dia., correctly treated.	M†	0.45 in. dia.	0.32 in.	45	0.01 in.	5	61.2	1.8	2.9	0.97
M†	0.45 in. dia.	0.33 in.	45	0.01 in.	12	88.9	4.6	5.2	1.12	Nickel Chrome Steel, Bar 1, 1 in. dia., correctly treated.	N†	0.45 in. dia.	0.32 in.	45	0.01 in.	5	63.0	1.6	2.5	0.99	
P†	10 mm.	8 mm.	0	1.0 mm.	8	87.0	7.6	8.8	1.10	Nickel Chrome Steel, Bar 1, 1 in. dia., correctly treated.	P†	10 mm.	8 mm.	0	1.0 mm.	4	68.5	2.0	2.9	1.08	
Series XXVI Nickel Chrome Steel, Bar B, 1 in. dia., heat-treated commercially.	A*	10 mm.	8 mm.	45	0.25 mm.	8	59.9	2.6	4.3	...	Nickel Chrome Steel, Bar 1, 1 in. dia., correctly treated.	Sq.S†	10 mm.	8 mm.	45	0.25 mm.	3	57.3	3.2	5.6	0.90
M†	0.45 in. dia.	0.33 in.	45	0.01 in.	12	28.5	4.5	15.7	1.16	Nickel Chrome Steel, Bar 1, 1 in. dia., correctly treated.	Sq.U†	10 mm.	8 mm.	0	1.0 mm.	3	69.1	2.5	3.7	1.09	
P†	10 mm.	8 mm.	0	1.0 mm.	8	68.4	4.2	6.1	1.14	Series XXXIV Nickel Chrome Steel, Bar 4, 1 in. dia., correctly treated.	A*	10 mm.	8 mm.	45	0.25 mm.	5	10.9	1.1	10.9	...	
Series XXVII Nickel Chrome Steel, Bar F, 1 in. dia., heat-treated commercially.	A*	10 mm.	8 mm.	45	0.25 mm.	8	24.6	3.1	12.7	...	Nickel Chrome Steel, Bar 4, 1 in. dia., correctly treated.	M†	0.45 in. dia.	0.33 in.	45	0.01 in.	5	18.1	0.5	2.8	1.68
M†	0.45 in. dia.	0.33 in.	45	0.01 in.	12	10.5	4.5	15.7	1.16	Nickel Chrome Steel, Bar 4, 1 in. dia., correctly treated.	V†	10 mm.	8 mm.	45	0.25 mm.	3	13.2	2.6	19.5	1.21	
P†	10 mm.	8 mm.	0	1.0 mm.	8	40.6	6.6	16.2	1.65	Nickel Chrome Steel, Bar 4, 1 in. dia., correctly treated.	E	10 mm.	8 mm.	45	0.25 mm.	3	20.2	0.9	4.5	1.85	
Series XXVIII Bright drawn Mild Steel, Bar H, 1 in. dia., untreated.	A*	10 mm.	8 mm.	45	0.25 mm.	8	9.6	2.1	21.6	1.10	Nickel Chrome Steel, Bar 5, 2 in. dia., correctly treated.	A*	10 mm.	8 mm.	45	0.25 mm.	5	54.4	1.0	1.9	...
M†	0.45 in. dia.	0.33 in.	45	0.01 in.	12	11.5	1.3	12.2	1.10	Nickel Chrome Steel, Bar 5, 2 in. dia., correctly treated.	M†	0.45 in. dia.	0.32 in.	45	0.01 in.	5	63.3	1.0	1.6	1.16	
P†	10 mm.	8 mm.	0	1.0 mm.	8	48.1	11.5	23.8	5.03	Nickel Chrome Steel, Bar 5, 2 in. dia., correctly treated.	S†	10 mm.	8 mm.	45	0.25 mm.	5	59.4	0.5	0.8	1.09	
										Nickel Chrome Steel, Bar 5, 2 in. dia., correctly treated.	V†	10 mm.	8 mm.	45	0.25 mm.	4	68.4	1.4	2.1	1.26	
										Nickel Chrome Steel, Bar 6, 2 in. dia., correctly treated.	A*	10 mm.	8 mm.	45	0.25 mm.	5	56.2	2.6	4.6	...	
										Nickel Chrome Steel, Bar 6, 2 in. dia., correctly treated.	M†	0.45 in. dia.	0.32 in.	45	0.01 in.	5	64.2	3.4	5.2	1.14	
										Nickel Chrome Steel, Bar 6, 2 in. dia., correctly treated.	S†	10 mm.	8 mm.	45	0.25 mm.	5	56.6	3.9	6.9	1.01	
										Nickel Chrome Steel, Bar 6, 2 in. dia., correctly treated.	V†	10 mm.	8 mm.	45	0.25 mm.	5	62.7	4.1	6.5	1.12	
										Series XXXV Nickel Chrome Steel, Bar 7, 2 in. dia., correctly treated.	A*	10 mm.	8 mm.	45	0.25 mm.	5	58.3	2.4	4.2	...	
										Nickel Chrome Steel, Bar 7, 2 in. dia., correctly treated.	M†	0.45 in. dia.	0.32 in.	45	0.01 in.	5	65.1	3.8	5.9	1.12	
										Nickel Chrome Steel, Bar 7, 2 in. dia., correctly treated.	N†	0.45 in. dia.	0.32 in.	45	0.01 in.	4	65.1	1.9	2.9	1.12	
										Nickel Chrome Steel, Bar 7, 2 in. dia., correctly treated.	P†	10 mm.	8 mm.	45	0.25 mm.	4	72.7	1.8	2.5	1.25	
										Nickel Chrome Steel, Bar 7, 2 in. dia., correctly treated.	A*	10 mm.	8 mm.	45	0.25 mm.	5	56.4	1.3	2.3	...	
										Nickel Chrome Steel, Bar 7, 2 in. dia., correctly treated.	M†	0.45 in. dia.	0.32 in.	45	0.01 in.	5	69.1	0.9	1.4	1.10	
										Nickel Chrome Steel, Bar 7, 2 in. dia., correctly treated.	S†	10 mm.	8 mm.	45	0.25 mm.	5	52.7	1.2	2.2	0.94	
										Nickel Chrome Steel, Bar 7, 2 in. dia., correctly treated.	V†	10 mm.	8 mm.	45	0.25 mm.	5	59.4	2.3	3.8	1.05	
										Nickel Chrome Steel, Bar 9, 2 in. dia., correctly treated.	A*	10 mm.	8 mm.	45	0.25 mm.	5	32.1	1.9	6.0	...	
										Nickel Chrome Steel, Bar 9, 2 in. dia., correctly treated.	M†	0.45 in. dia.	0.32 in.	45	0.01 in.	5	43.1	1.7	4.0	1.34	
										Nickel Chrome Steel, Bar 9, 2 in. dia., correctly treated.	S†	10 mm.	8 mm.	45	0.25 mm.	5	28.5	3.1	10.7	0.89	
										Nickel Chrome Steel, Bar 9, 2 in. dia., correctly treated.	V†	10 mm.	8 mm.	45	0.25 mm.	5	37.6	1.7	4.0	1.17	

TABLE 5—COMPARISON OF TEST RESULTS ON ROUND AND SQUARE TEST PIECES

Material	Type of Test Piece	DIMENSIONS OF TEST PIECES				Number of Tests	RESULTS OF TESTS			
		Size of Test Piece	Thickness at Groove or Notch	Angle of Groove or Notch	Radius at Root		Mean Energy Absorbed	Average Variation from Mean	Percentage Variation from Mean	Ratio of Mean Results to Mean Results on Standard Square Test Piece
Series XXXVI Carbon Steel, Bar 38, $\frac{1}{4}$ in. dia., heat-treated commercially.	S [†] U [†]	10 mm. 10 mm.	8 mm. 8 mm.	45 ⁰ 0.25 mm. 1 mm.	3141.0 3153.9	0.4 11.5 7.5	0.3 7.5	...	...	...
Series XXXVII Carbon Steel, Bar 48, $\frac{1}{4}$ in. dia., heat-treated commercially.	S [†] U [†]	10 mm. 10 mm.	8 mm. 8 mm.	45 ⁰ 0.25 mm. 1 mm.	3159.8 3163.5	13.4 12.3	8.4 7.5	...	...	...
Series XXXVIII Nickel Chrome Steel, Bar 3B, $\frac{1}{4}$ in. dia., heat-treated commercially.	A [*] M [†] N [†] P [†] S [†] U [†]	10 mm. 0.45 in. dia. 0.45 in. dia. 10 mm. 10 mm. 10 mm.	8 mm. 0.33 in. 0.32 in. 8 mm. 8 mm. 8 mm.	45 ⁰ 0.25 mm. 0.01 in. 0.01 in. 45 ⁰ 0.25 mm. 1 mm.	66.2 69.4 73.8 71.6 63.6 81.2	6.5 3.4 5.2 2.8 3.5 6.2	9.8 4.9 7.0 3.8 5.5 7.6	...	...	...
Series XXXIX Nickel Chrome Steel, Bar 4B, $\frac{1}{4}$ in. dia., heat-treated commercially.	A [*] M [†] N [†] P [†] S [†] U [†]	10 mm. 0.45 in. dia. 0.45 in. dia. 10 mm. 10 mm. 10 mm.	8 mm. 0.33 in. 0.32 in. 8 mm. 8 mm. 8 mm.	45 ⁰ 0.25 mm. 0.01 in. 0.01 in. 45 ⁰ 0.25 mm. 1 mm.	75.5 80.7 81.0 80.7 91.2 95.8	2.8 2.3 2.3 1.7 1.8 4.3	3.8 2.3 2.9 2.1 2.0 4.5	...	...	...
Series XL Nickel Chrome Steel, Bar 3V, $\frac{1}{4}$ in. dia., heat-treated commercially.	A [*] M [†] N [†] Q [†] S [†] V [†]	10 mm. 0.45 in. dia. 0.45 in. dia. 10 mm. 10 mm. 10 mm.	8 mm. 0.33 in. 0.32 in. 8 mm. 8 mm. 8 mm.	45 ⁰ 0.25 mm. 0.01 in. 0.01 in. 45 ⁰ 0.25 mm. 1 mm.	30.6 37.0 31.9 32.0 26.6 30.9	0.6 1.5 0.9 1.5 0.6 1.2	1.8 4.1 2.9 4.7 2.4 4.0	...	...	...
Series XLI Nickel Chrome Steel, Bar 4V, $\frac{1}{4}$ in. dia., heat-treated commercially.	A [*] M [†] N [†] Q [†] S [†] V [†]	10 mm. 0.45 in. dia. 0.45 in. dia. 10 mm. 10 mm. 10 mm.	8 mm. 0.33 in. 0.32 in. 8 mm. 8 mm. 8 mm.	45 ⁰ 0.25 mm. 0.01 in. 0.01 in. 45 ⁰ 0.25 mm. 1 mm.	36.2 39.5 36.2 40.5 27.9 33.7	2.7 4.2 2.7 4.2 1.6 2.0	7.4 10.5 7.5 10.3 5.7 5.8	...	...	...
Series XLII Nickel Chrome Steel, Bar 3J, $\frac{1}{4}$ in. dia., air-hardened.	A [*] M [†] N [†] Q [†] S [†] V [†]	10 mm. 0.45 in. dia. 0.45 in. dia. 10 mm. 10 mm. 10 mm.	8 mm. 0.33 in. 0.32 in. 8 mm. 8 mm. 8 mm.	45 ⁰ 0.25 mm. 0.01 in. 0.01 in. 45 ⁰ 0.25 mm. 1 mm.	12.4 10.8 11.8 19.2 11.5 19.9	1.3 1.5 1.2 1.2 1.3 1.2	10.3 13.7 10.5 6.1 11.6 5.8	...	...	...
Series XLIII Nickel Chrome Steel, Bar 4J, $\frac{1}{4}$ in. dia., air-hardened.	A [*] M [†] N [†] Q [†] S [†] V [†]	10 mm. 0.45 in. dia. 0.45 in. dia. 10 mm. 10 mm. 10 mm.	8 mm. 0.33 in. 0.32 in. 8 mm. 8 mm. 8 mm.	45 ⁰ 0.25 mm. 0.01 in. 0.01 in. 45 ⁰ 0.25 mm. 1 mm.	9.4 8.4 10.3 14.9 9.3 17.0	1.3 0.5 2.7 3.1 0.5 0.9	13.3 5.4 25.9 20.6 5.0 5.0	...	...	...

^{*}Standard square test pieces, type A[†]Standard round test pieces, types M and N[‡]Square test piecesAll tests carried out on Izod machine except those marked [†]Tests marked [‡] carried out on Charpy machine

pering temperature will usually result in a serious decrease in the notched bar test result, without corresponding alteration in the tensile test, and this fact has been used to obtain the divergent notched bar tests reported in Series XVII, XVIII, XXIII, XXIV, XXIX, XXX, XXXIII, XXXIV, and XXXV.

SLOW-BENDING TESTS ON NOTCHED BARS

It appeared desirable to investigate the question whether the tests made in the pendulum machines were essentially "impact" tests. With this end in view it was decided to make a number of tests in some machine which would introduce no effect of inertia, and in which the

load was slowly applied by static pressure. For this purpose a number of slow-bending tests on notched bars were made in an ordinary Brinell machine, the deflections of the specimen for different loads being measured by a microscope. This apparatus had the advantage of being easily fitted to a machine which was available for the purpose in view. A comparison of the results obtained with those obtained in the Izod machine from square test pieces with similar notches is shown in Table 6.

TABLE 6—COMPARISON OF TEST RESULTS OBTAINED FROM NOTCHED BAR SLOW-BENDING TESTS WITH MEAN RESULTS OBTAINED FROM SQUARE IZOD TEST PIECES WITH SIMILAR NOTCHES

Material	For Type of Notches See Test Pieces	Mean Energy Absorbed in Slow-Bending Test	Mean Energy Absorbed by Corresponding Izod Test Pieces	Ratio of Mean Energy Absorbed by Slow-Bending Test Pieces to Mean Result from Izod Test Pieces
Series XXIII Bar SS3..... Bar SS4.....	Types	Ft.-lb.	Ft.-lb.	
		58.4 12.5	A, 81.7 A, 14.7	0.72 0.84
Series XXIV Bar SH3..... Bar SH4.....	A and S	50.1 10.2	A, 65.8 A, 11.0	0.76 0.93
Series XXIX Bar SS5..... Bar SS6.....		58.5 11.6	A, 70.5 A, 15.9	0.74 0.73
Series XXX Bar SH5..... Bar SH6.....		50.2 7.3	A, 36.5 A, 10.1	0.79 0.72
Series XXXIII Bar 1..... Bar 2..... Bar 3.....	P and U	49.5 16.5 50.1	P, 68.5 P, 31.4 P, 71.2	0.72 0.53 0.70
Series XXXIV Bar 4..... Bar 5..... Bar 6.....	A and S	8.3 42.1 43.8	A, 10.9 A, 54.4 A, 56.2	0.76 0.77 0.78
	Bar 4..... Bar 5..... Bar 6.....	11.7 48.6 45.7	Q, 18.1 Q, 63.3 Q, 64.2	0.65 0.77 0.71
Series XXXV Bar 7..... Bar 8..... Bar 9.....	A and S	48.4 43.6 39.7	A, 58.3 A, 56.4 A, 32.1	0.83 0.77 1.24
	Bar 7..... Bar 8..... Bar 9.....	53.8 49.9 44.3	Q, 65.1 Q, 62.1 Q, 43.1	0.83 0.80 1.03

It will be seen that the slow-bending tests have been made in several cases on the same material in the correctly treated and incorrectly treated conditions. If the results are plotted the curves for the correctly treated specimens will show that the deflection is at first proportional to the load, and then departs from proportionality in a manner somewhat similar to that shown by the ordinary tensile test. After reaching a maximum the load then gradually diminishes more and more slowly until the material has bent a considerable distance. These tests were usually carried out until the specimen had been bent to about the same included angle, 120 deg., as is usually obtained from a correctly treated specimen in the Izod machine. This point was taken as the end of the test, as it was desired to determine to what extent the results obtained from the slow-bending tests were similar to those obtained from the ordinary tests in the Izod pendulum machine.

For the incorrectly treated specimens the curve showing the rise of load with deflection is very similar to that obtained from the correctly treated steel, but the specimen breaks suddenly at a point when the load is slightly lower than the maximum reached by the correctly treated specimen, and though there is very little inertia effect to be expected from the static pressure of the Brinell

SOME EXPERIMENTS ON NOTCHED BARS

machine, the slow-bending test piece broke suddenly and the parts flew out of the machine in a manner similar to the breaking of a test piece giving a low value in the Izod machine.

It would appear, therefore, that the material in the incorrectly treated condition is liable to rupture at any point where there is a relatively sharp internal corner or a fillet with a small radius, if a part possessing such corners is subjected to either a shock or to an excess load from any cause, and the same would of course apply in any case where the steel has a small defect. The slow-bending tests confirm the results obtained from the notched bar tests in the pendulum machine in a very remarkable manner, although they do not give exactly the same result as is obtained from the pendulum machine.

The disparity between the results obtained from the two tests may be explained by considering the manner in which the total energy is dissipated in the pendulum testing machine. The energy which is recorded by the machine represents the sum of the following components:—

- (a) The energy absorbed in stressing the test piece up to the limit of proportionality of load and deflection.
- (b) The energy absorbed in producing plastic and elastic strains in the metal when loaded beyond the limit of proportionality.
- (c) The energy absorbed in doing local injury to the test piece at the point which is struck by the knife edge of the pendulum.
- (d) The energy absorbed in the production of sound.
- (e) The energy transmitted to the vise or supports of the test piece in the testing machine and dissipated in these parts.
- (f) The energy absorbed by vibrations set up in the pendulum and the framework of the machine.

The velocity of propagation of stresses in steel may be judged by the fact that the velocity of sound travelling along a bar of steel is over 16,000 ft. per sec. Sound is transmitted along the bar by fluctuating stresses between the particles of the bar, and it will therefore be seen that for stresses within the limit of proportionality the speed of the test in the pendulum machine is relatively slow, and it is improbable that there is any difference in the two tests in the amount of energy absorbed under section (a) above.

With reference to (b) the energy absorbed in the plastic flow of the material is probably somewhat less

when the test piece is broken slowly than when it is broken more quickly in the pendulum machine. The local damage done to the specimen (c) appears to be less in the slow-bending test than in the pendulum test if we can judge from the appearance of the surface of the specimen after fracture; (d), (e), and (f) are practically absent in the slow-bending test, and probably account for the greater part of the deficiency in value between this test and the test in the pendulum machine.

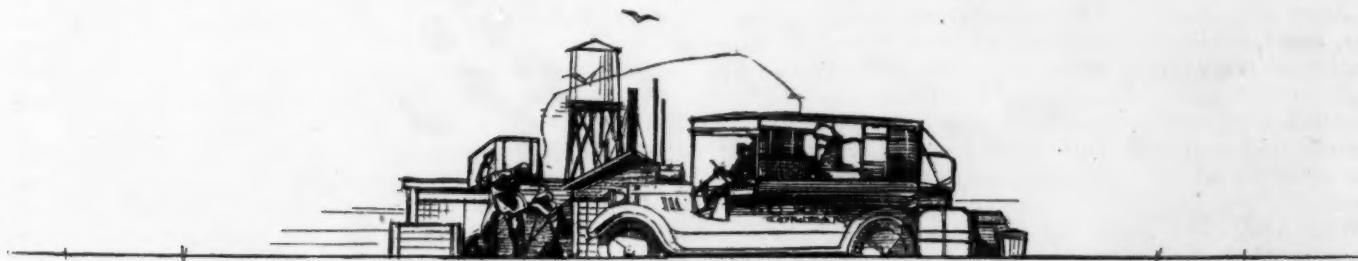
The advantages of using the pendulum machine for making the notched bar tests are, however, obvious, and as the specification values for acceptance tests must in all cases be arranged empirically by testing the material in a machine of the type which will ultimately be used, there appears to be no reason why the notched bar tests should not continue to be made in the usual manner in such machines, even though it appears that the result obtained credits the material with rather higher values than those obtained by the slower method.

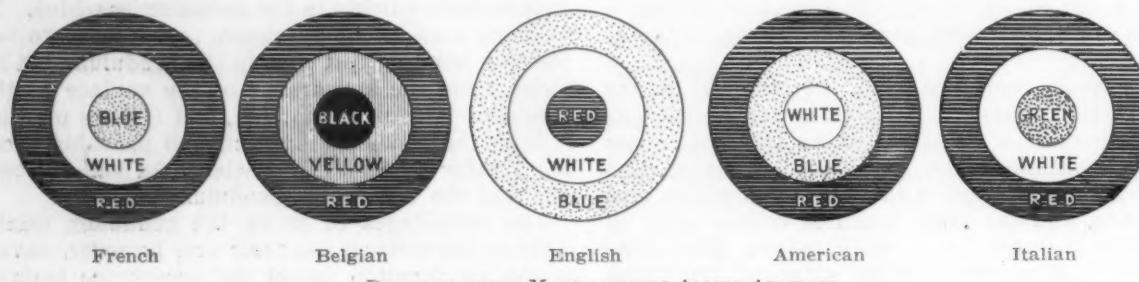
CONCLUSIONS

The principal conclusions which can be drawn from these experiments appear to the author to be as follows:—

- 1 The round test pieces, types M and N, are sufficiently good approximations to the standard square test piece, type A, for use in acceptance tests on steel, where facilities for machining the square test pieces are lacking or are insufficient.
- 2 Notched bar test pieces with relatively large radii at the roots of the notches are insensitive and therefore unsatisfactory.
- 3 The tensile test, even where an extensometer is used, does not give any satisfactory criterion for detecting the condition of the material which gives low values on the notched bar tests.
- 4 The notched bar test made in a pendulum testing machine is not essentially an "impact" test.

5 The notched bar test can be made in either the Charpy or the Izod pendulum machines, and should give similar values, except for very tough specimens. This similarity could probably be increased even for the higher values if the span for the 10-mm. square test piece were made 44 mm. in place of 40 mm., or the length of the Charpy specimen reduced so that specimens which are not entirely broken through are bent to the same included angle as in the Izod machine.





The Future of the Airplane Business

By PRESIDENT C. F. KETTERING

DETROIT SECTION MEETING ADDRESS

Illustrated with PHOTOGRAPHS

IT is sometimes of interest to stop and analyze a proposition as much talked of as the airplane, to understand just what it is.

You hear people say: "Well, it is going to be as big an industry as the automobile industry," or, "Well, we shall see them as thick as Fords." A great many people prophesy by just taking a random shot, but I believe that if we are interested in the future of the airplane business and analyze this problem we shall at least know along what lines, along what roads we should go if we are to get anywhere.

The future of the airplane business depends largely upon many external developments. Before discussing these, it may be of interest to many of you to hear something about past development in aeronautics, because these portray more clearly what the problems of the future really are.

The Wright brothers, when they first became interested in flying, had no idea of building a machine. They had read the works of Lilienthal, a German, who had done some gliding and wrote wonderfully about it. As they had always taken a month's vacation each year, they thought it would be fine, instead of fishing and hunting, to build one of these gliders and go some place and glide. As two of the essentials of successful gliding are wind and sand, they wrote to the Weather Department for information, were referred to the postmaster at Kitty Hawk, and from him learned what a fine place it would be to do gliding.

The Weather Department stated that the place had an average wind of 30 miles an hour throughout the year. It developed, however, that one day they did not have any, and the next day they had 60 miles. A good illustration of the value of averages. They went there with a glider built after ideas taken from Lilienthal—remember there were no formulas or anything of that kind then—and tried gliding. The thing did not work out as per program at all, but they learned a lot that year about it.

When they came home they did some figuring, built a crude wind tunnel and tried some experiments. Next year they built another glider and went back. That did not pan out at all. They found that their figures were wrong again.

Finally they went down, thinking they might as well try something; so they turned the glider around and glided it backwards, just as a matter of experiment, and the thing worked. Now, to me that is a perfectly natural thing. If most engineers were to do just the reverse of what they have planned they would succeed much oftener than they do. However, that gave them a clue. They came back for more wind-tunnel experiments and finally hit upon the fundamentals of the control of an airplane, upon something of the quantitative values. The third year they got perfectly wonderful results.

Then they said: "If we only had an engine in this we could fly." Thus the engine problem bobbed up for the first time. They built a four-cylinder, horizontal engine, with the dimensions taken from a 2-hp. farm engine, and this gave them 9 hp. the first time they ran it. Then they got a little more ambitious and finally screwed the engine up to 12 hp., and the first flight of the machine with about a 40-ft. wing-spread, and weighing 750 lb. with the operator in it, was made with a 12-hp. engine.

CONTROL AND OPERATION

Now, the principles of control and operation, the fundamentals of airplane construction have not changed since that first flight. I know a great many of you understand perfectly well the whole control of an airplane but just for the sake of placing us all on an even keel, I shall outline briefly the very simple phenomena of an airplane.

When it is off the ground, an airplane can turn around on any one of three axes, and each of these has its own particular type of control. The one particular new idea that the Wright brothers put into the control of the plane is what is known as "lateral control" by the warping of the wings. If the machine tipped over to the right, they turned the tip of that wing down and the tip of the other wing up. Later on they found it was easier to cut a piece out of this tip and move that, instead of working the tip, and got the aileron control. The horizontal control is operated by an elevator which when raised at the tip pushes the tail down and causes the plane to rise. To go down, the tail is raised.

The rudder operates like that of a boat, but in addi-

THE FUTURE OF THE AIRPLANE BUSINESS

tion the banking of the plane must be considered, and the big problem in flight, the relation existing between rudder control and aileron control, must be solved. If the rudder is simply thrown around to the right the airplane may not turn at all. It may slide outward. If it does not start to turn, immediately the end of the wing which travels starts to rise and if not stopped will turn up so far as to cause the plane to slip around. You do not have to bank an airplane on the turns but must avoid over-banking, because the minute you start to turn, the outer wing starts to climb up, and then you have to adjust your aileron just opposite and hold it at the proper angle. In this connection a lot of work had to be done, but those things are now reduced to simple problems because of the fact that we have power. With only 12 hp. the least bit of overbalance became serious. The study of this very big problem resulted in a complete analysis of the quantities involved and has been a source of information for us all.

That part of the airplane has remained fixed ever since. It is not changed on any planes made to-day. There are, however, different ways of moving those controls. They used to move the aileron with one shoulder, and various things like that, but at present the whole thing has dropped down to a standard method known as the Dep control, and this is used either in connection with a wheel or a stick. You have a vertical standard with a wheel, like an automobile steering-wheel. If the machine tips to the right, you turn the wheel to the left, and vice versa. The vertical standard when moved forward and backward controls the up and down, and a bar moved

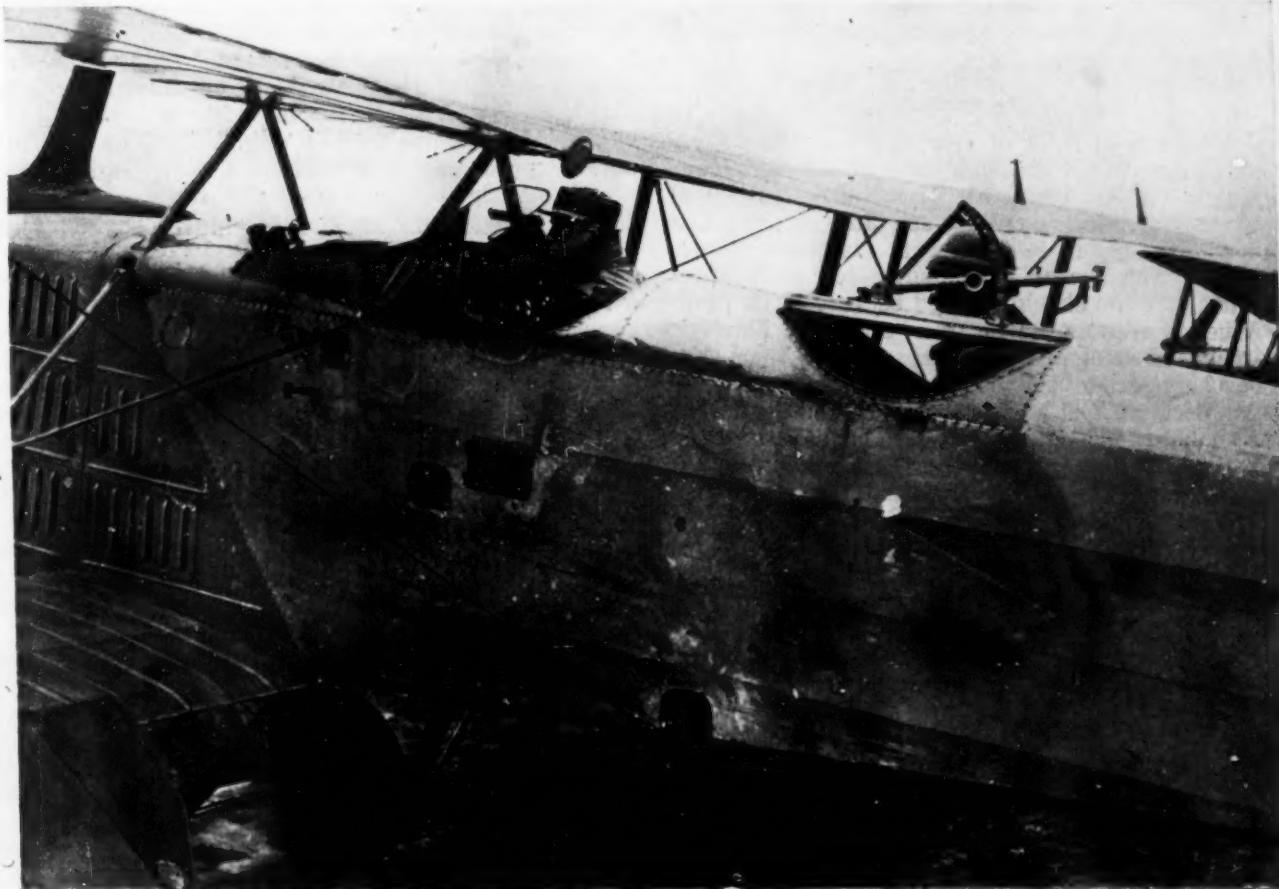
by the feet controls the rudder. If you take the wheel off you simply have a stick which you move right or left to get lateral balance, and forward or backward for horizontal; the rudder control remains the same. A wheel is used on the larger planes to get more power.

CIVILIAN USE OF AIRPLANES

Now, common conversation runs something like this: "Well, this airplane business is going to be a great thing after the war; we are training thousands of aviators and when those boys come back from the front they are all going to have flying machines."

I do not doubt that they would all like to have flying machines, but I have been figuring and do not see just how they are going to get them. An engine costs about \$15 per horsepower, and an expert would certainly not be satisfied with anything under 100 hp. That is \$1,500 for the engine. A cheap good airplane would cost about \$2,000. There must be a hangar for it, and a field of at least 40 acres. Then if the flyer does not happen to be a mechanic he will need a motorman and a planeman. Just how can a man afford a thing like that on a salary of \$25 or \$50 a week? The foundation of an airplane is the engine, and until somebody can manufacture one to sell down to at least \$5 per horsepower, the plane will be more of a yachting than a Ford problem.

Just the same, there may be a popular airplane in the future. It will have a little engine of say 40 hp., weighing $2\frac{1}{2}$ lb. per hp., and 15 or 20 ft. spread—something to sell for perhaps \$1,500. Of course, it cannot be com-



© Committee on Public Information
A PORTION OF A TWO-SEATER PLANE SHOWING THE RELATIVE POSITIONS OF THE PILOT AND THE OBSERVER

plicated and anybody can fix it. It can be kept on the premises or in a public hangar.

There is another opening for airplane manufacturers, however. The carrying of mail, freight and express matter is still in its trial period. It will, in the end, come down to a question of cost. There is no doubt that this undertaking will be carried out by one of our great corporations or the Government. The type of plane must be large and heavily motored, and is to be expensive.

A lot of things must be done before much that we predict for the airplane can possibly come true. What would we think of navigation if we did not have harbors and docks, lighthouses and buoys, and the rest that goes with traffic on the seas? That is exactly the state of transcontinental airplane work to-day. We must have airplane routes mapped out, with wireless signal stations every 20 or 25 miles. We must have harbors with proper landing places for different types of planes and facilities for receiving different classes of goods. We must duplicate for airplanes all the detail worked out for our railroads.

Now, as to who will lay out these routes across country nothing is known. The Chambers of Commerce of different towns and villages may get together on an airplane road from here to Dayton, and on that 224 miles we will put in say 20 stations. Our electrical engineers can design for us a very clever wireless outfit that will go right on top of poles, and we should make arrangements with the American Telephone & Telegraph Co. to use the tops of its poles. We can then string a pair of wires to handle these stations, and put up signal stations like little lighthouses, which we shall not see with our eyes but know of through the little antennae that hang down from the plane.

STRUCTURAL FEATURES

From a structural point of view there is still a great deal to be said and a great deal of work to be done. Many people think that airplanes should be made largely of metal, as they are on the other side. Just at present it is more a question of selecting what materials we can get. All-steel construction has its advocates, while others think that aluminum should be used because of its lightness. When we come to consider strength, however, things made of steel are sometimes lighter than they would be of aluminum. At the present time, after studying the subject, we feel a little safer in a wood airplane than we should in one of steel.

As to wing covering, it has already been suggested that rust-proof iron, rolled down so thin that the light would almost shine through, be employed. All this is good. All along the line there will be experiments in structural changes and improvements as new materials are developed. Men who are scientifically inclined will do a great work in the development of these materials.

The metallurgists and the material men all the way through, in wood and cloth and so forth, and the heat treating experts, already seeking to prevent crystallization, can revel in that section of the airplane industry.

As to new forms for the machines, wing curve and so on, experts need to get busy with wind tunnels, of which we have very few high-speed ones in the country; that is, tunnels with a draft of 100 to 150 miles an hour.

THE ENGINE

Getting back to the engine situation, for that is the biggest proposition in the future development of the air-

plane, its running life must be lengthened. If we are to open mail routes between New York and Chicago, we shall have to have roundhouses as the railroads do. Even in high-power jobs the engine must be studied from the point of economic production and long life.

The subject of engine economy is very interesting, especially to the Society of Automotive Engineers. I am perfectly willing to make a rash prediction tonight, and it is that inside of five years we will see the beginning of the end of the present type of internal-combustion engines. I think the Lord has tolerated this foolishness of throwing away 90 per cent of the power in fuel as long as he intends to, and we must act and help ourselves a little. The average automobile engine is about 10 or 12 per cent efficient. We are sending out an awful lot of energy into thin air through water-jackets and exhaust pipes, and the minute we begin to get engine economy we are doing things worth while, things making for cheaper operation. The great tractor and truck industries will be augmented to a degree we cannot anticipate by improvements in automobile engines.

The greatest thing civilization has had thus far is the internal-combustion engine. For the first time in the history of the world mankind has a detached power unit of any considerable size. In the airplane it is a 400-hp., self-contained prime-mover. We could not have planes if it were not for that. In the automobile the whole industry is built around the fact that we have a detached power unit in which we carry fuel in liquid form.

Now, a great deal of our progress and most of our development along the line of the internal-combustion engine have been made by mechanical improvements in existing mechanisms, and we have not gone thoroughly into the study of thermal relations in this matter. There is where we must do some intensive study. When we stop to think of it, efficiency in an airplane will be a very important factor, because with, say, three 400-hp. engines in one plane the fuel proposition gets to be a big one. Suppose we have a three Liberty-engined plane, and do not fly it with wide-open throttles, but use only 25 gal. of gasoline per hr. per engine. That is 75 gal. per hr. To make a flight from New York to Chicago in 10 hr. we should need a 750-gal. gasoline tank and carry 4200 lb. of fuel on board. The more fuel, the bigger the engine, the bigger the engine, the wider the wing-spread, the wider the wing spread the more fuel needed. It is a costly circle and in it are the two important factors, engine weight and engine economy. If we can improve the engine even 25 per cent in its economy, a thousand pounds are immediately taken off the plane, to go into useful load or reduce the size of the plane. On improvement in engine economy rest tremendous possibilities of extending the range of present airplane development. From no matter what angle we analyze this subject, we come back to the same point—engine economy and engine weight.

Engines divide themselves into two general classes, air-cooled and water-cooled. We have as yet done very little in this country with the subject of air-cooled engines. I think the automobile industry is partly responsible for this, because we have had only one air-cooled car, but if there is any place in the world where an air-cooled engine will work to advantage it is in an airplane.

The English have developed one very interesting air-cooled engine, known as the A.B.C., a small type of which, 40 hp., weighs about 76 lb. complete, magneto, carburetor and everything. That is the whole power-plant, that 76 lb., while to a water-cooled engine of a

THE FUTURE OF THE AIRPLANE BUSINESS

given pound weight we have to add from 0.6 to 0.7 lb. per hp. for radiation and so forth. Starting with these English engines, fundamentally low in weight as they have been able to get them, we have an incentive for developing something new.

There are very many phases of the airplane business as a future commercial development. Things are going to happen, and we shall get certain advantages as time goes on, just as we did in the automobile business, in the least expected ways.

MILITARY AIRPLANES

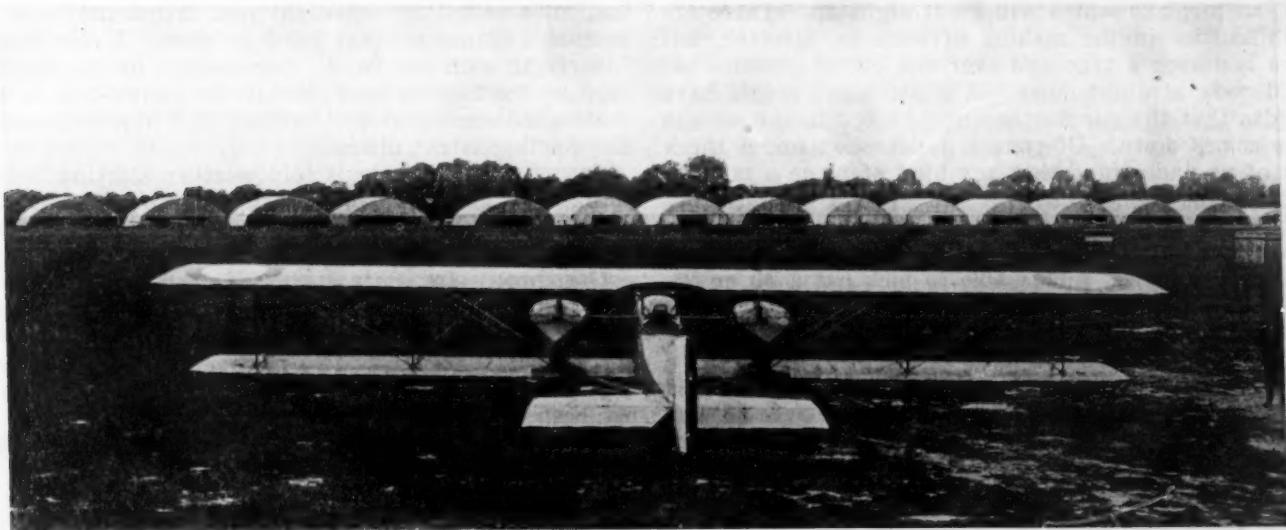
On the military side of aviation so much that is misinforming is given out that the average man who has not followed the subject can become very much confused. In the first place, just as a brief résumé, the fighting airplane can be divided very roughly into three general classes: The fighting plane, the day bombing plane, and the night bombing plane. The fighting machine, like the pleasure car, can be a single passenger, a two-passenger, or a touring car. It can be whatever you want to make it, provided it is easily maneuvered. It carries

fighter may not be anything in speed but it must be maneuverable. In the bombing machine you can distribute the weight, and the machines are not as active in turning and that sort of thing, or as easily handled. Otherwise their functions may be exactly the same. There is a wide range of types of machine that can be called reconnaissance, photographic or artillery observation, and that sort of thing.

The largest type of machine is the night bomber, which corresponds to a 10-ton truck. It may have one or more big engines, and its principal feature is not speed but carrying capacity for a tremendous load, as it has a definite task.

The types of engines for these machines are various. On single-seater fighters are rotary, fixed and radial engines, that is, those which do not turn around, and others with cylinders or crankshaft which turn around. These may have six, eight or twelve cylinders. The Germans have always used the six-cylinder Mercedes. The eight-cylinder Hispano and various other types are used by the Allies.

Beginning with the two-place fighter, it is necessary



A TYPICAL AVIATION FIELD WITH THE HANGARS IN THE BACKGROUND

principally machine guns, and its one function is to fight. The single-seater fighter is a small plane with a 100, 150, 180 or 200-hp. engine. It has very good climbing ability, and a good range of speed up to perhaps 125 miles an hour. The two-place fighter may carry two guns forward and two guns aft, those forward being fixed and shooting in synchronism with the propeller. The rear guns are on a turret, and the gunner goes out looking for trouble.

A day bombing machine is simply a good, high-grade aerial truck, traveling relatively fast. It can carry 300, 400 or 500 lb. of bombs, machine guns, wireless apparatus, photographic apparatus and oxygen apparatus. Practically everything you can think of is loaded on to those day bombers, because they have wonderful utility and a wonderful range of work. They must be pretty good machines in the way of speed and climbing, because day bombing is done from very high altitudes. They have to protect themselves when encountered, and must be very active.

The principal difference between a two-place fighter and a two-place bomber is in maneuverability. The

to increase the horsepower to 220, 350 or 400, if the machine is able to carry that much.

WING LOAD AND SPEED

To give some idea of the way to make simple preliminary calculations, I might say this: A certain wing area on a given machine will carry so much per square foot. This we know from experience, just as an architect knows how many pounds per square foot a floor will bear. We may decide to carry 9 lb. per sq. ft. on a given wing, which is easily done, without remembering that this will make it necessary to land the plane at about 65 miles an hour. In fact, the plane must travel faster than 60 miles an hour in order to carry 9 lb., unless we have a very exceptional wing curve. The minute we specify wing load we fix the landing and starting speeds. If these are to be cut down it will be necessary to cut down either the load or the extent of wing. One of the first things to determine in aircraft calculations is what the wing load is to be. With the ordinary military airplane a fair average wing load for a day bombing machine is about 8 lb. per sq. ft., and about 1 hp. for 10 lb. weight;

that is, a 400-hp. Liberty engine will handle very satisfactorily a plane weighing 4000 lb., and give a speed of perhaps 125 miles an hour. A few simple relationships exist as in a motor car or anything else, and the whole matter becomes a compromise.

You who have ever thought of the matter at all, know exactly what makes an airplane fly. An airplane wing is very much like a steam turbine blade. The same formulas hold for the two. In the one case steam runs past the blade at a certain velocity, in the other case it is air.

We have learned that for every pound of lift in shooting a plane surface through the air, we must have a certain pull on its entering edge. The propeller gives the pull, and what we are interested in is how much lift we can get for a pound of pull. Some wing curves will give a great lift for a small pull, but as the speed begins to go up they offer abnormal resistance. Another curve will not give quite as much lift at low speed, but in building fast airplanes that does not count. The thing to do is to select the correct ratio for the work to be done and plane curves that absolutely correspond with this ratio.

An idea that is revived from time to time is that we want an airplane which will go straight up. There are no difficulties in the making of such an airplane, but if we had such a type and ever ran out of gasoline we would come straight down. A great many people have the idea that the minute the engine stops in the air the plane comes down. Of course it does not, and I think most of us understand that any kind of plane a mile up has an eight-to-one glide. It can glide 8 miles in any direction before coming down. This gives time to select a place to land. If the aviator can see the ground, he has considerable choice, and is able to pick out a 40 or 50-acre field in a circle with a diameter of 8 miles. If the plane is 2 miles up it will take 16, 17 or 18 min. to come down, depending upon the type of machine.

I was talking with an English engineer one day and he said: "We don't care what the wing curves on our jobs are. The thing we are interested in is whether there is dirt in our gasoline tanks, or whether we have a strainer in our gasoline line; whether the throttle lever is going to come loose, whether this or that instrument is all right, or whether something will break." It is just the common simple mechanics of the job that causes us trouble on the front. It is not the wing surface or the size of the tail surface that matters; it is detail engineering.

In an industry as new as quantity production aviation, it is only natural that we should be somewhat below ideal conditions as yet. We have heard a great deal of criticism on the planes that have been built on this side. The facts have been grossly misrepresented, and many things reported were taken care of before the reports were circulated. Perhaps we have heard the last of our failure to produce aircraft in this country. It is particularly gratifying to have people from the other side who really know this game come over and tell us what they think about our production methods. It is consoling, and we can ignore what the fellow who does not know may say on the subject.

THE DISCUSSION

ELECTRICAL EQUIPMENT

QUESTION:—Will Mr. Kettering tell us about the electrical apparatus of an airplane?

MR. KETTERING:—As a first step every metal fitting

must be tied to every other metal fitting, because when you put on wireless the first thing you do is to bind everything with wires. The ignition apparatus is on the engine, of course. The planes are all equipped with wireless telegraph or telephone, principally the latter, which is very useful not only for a wireless transmission, but because it is the only means of communication between the crew. The wireless is good for a radius of 20 miles. In order to make electrical connection when the plane gets up high enough, the antennae reel is let out 300 or 400 feet. The wireless telephone is not a complex apparatus. With the bulbs one is able to do a lot of things, and the receiver is not even muffled. The aviator has his clothing heated with a current supplied by a 12-volt generator, driven by a fan, as a rule; and the generator is used for light and for heating gun barrels as well. The wiring work on an airplane is considerable.

There is no starting outfit. When the plane leaves the field there are many to do the cranking; the engine cannot stop in the air as the propeller will still run, and if something happens in the air that makes it necessary to land, the chances are that it will not be possible to start, anyhow. It is different with a seaplane, since as one cannot get out to crank a starter is really a necessity, and most seaplanes have them. Weight that is not useful is not wanted. Planes are not hard to start. I can start a Liberty 12 with one hand. One trouble in starting is a mixture too lean or too rich. If one knows how to stop the engine lean or stop it normal, and how to prime it, the starting is not difficult.

QUESTION:—How about cold weather starting?

MR. KETTERING:—You have to keep airplanes indoors, anyhow, so it is easy to fill them with hot oil and hot water before you take them out, just to warm them.

QUESTION:—Do you use a gun primer?

MR. KETTERING:—Yes. The great trouble with a gun primer with a Zenith carburetor is that you get too rich a mixture. I once saw two mechanics start a Hispano engine. It took them just 15 min. to do it. I know it had been stopped rich. After about 10 min. it dawned on one fellow that perhaps it was too rich. He closed the throttle and reversed the propeller, and then tried it, got one puff, and by repeating this got it started. It is just a simple matter of training the men on the priming.

THE COMPASS

QUESTION:—Why is the compass inaccurate?

MR. KETTERING:—Trouble with the compass is to be expected. There is a lot of iron and the compass is close to the engine, which causes the deflection.

QUESTION:—Has the gyroscope ever been used for a compass?

MR. KETTERING:—The trouble is that it brings into use a lot of apparatus—not only a compass, but alternating current and much paraphernalia. A gyroscopic compass must be kept running all the time.

QUESTION:—At what speed does the Liberty motor develop 400 hp.?

MR. KETTERING:—At about 1750 r.p.m.

QUESTION:—I have seen reports that the De Havilands are not suitable for diving. Why is that, if there is any truth in it?

MR. KETTERING:—It depends upon how fast you dive. I have dived a De Haviland as fast as it would dive. We had a machine partially wrecked at Dayton. A man took it up 15,000 ft. He had flown one but twice, and he nosed straight down and then brought it out squarely and the wings just left and it fell 15,000 ft. to the

ground. A De Haviland will dive about 180 miles an hour, but you want to pull it out gradually.

QUESTION:—I have heard the statement that the English De Haviland bomber carries as high as 2800 lb.

MR. KETTERING:—You understand that De Haviland is the name of the designer. There are different types; the 4, 8 and 10. One might be built to carry 1000 lb. and another model 5 tons.

QUANTITY PRODUCTION

QUESTION:—It would be interesting to hear about the quantity production of planes and plane parts.

MR. KETTERING:—At the beginning of the war the United States had about 100 airplanes, and I do not believe any were alike, because there had been no large orders. Ten or twelve was a large order and most of the fittings were made by hand. When we took this machine we analyzed it from a manufacturing standpoint, and we have gone ahead, not really making airplanes but parts to be assembled. We have made every type of tool that goes into the construction, but we could not go to work and make steel jigs and fixtures. We used $\frac{1}{2}$ -in. laminated wood, bored drill holes, put steel bushings in and used that for drill jigs. All of our parts are interchangeable. Any plane will fit any chassis.

QUESTION:—How about the assembling of planes in France?

MR. KETTERING:—The very first plane we sent over was in the air in 2 hr. after it was received at the aviation ground. They simply took it out, put it together, and everything fitted. That is quite an important factor.

QUESTION:—Why were the Capronis put out of production?

MR. KETTERING:—I do not know. You know that when dealing with foreign machines politics gets mixed in. We have the Handley-Page and another good machine here, the Glenn-Martin, and it is a question of whether they fit into the program.

SPRUCE AND WING COVERING

QUESTION:—What is the situation relative to spruce for wing beams and the covering material.

MR. KETTERING:—The spruce situation happens to be all clear now. Last fall when we started to build machines we needed spruce for wing beams. Some one asked, "Why can we not laminate them?" so we held a conference. We were accused of putting second-grade spruce in the airplanes. That was correct only so far as length was concerned. When the English people came over and went through our plant they found some solid wing beams and asked, "Do they let you use solid wing beams?" We had no trouble in getting solid wing beams when we were building only a hundred machines a year. We could then get any kind of timber we wanted, but when we got into quantity production it was different. The situation was cleared up by the use of laminations and substitute woods, fir and poplar. One foreign country does not want anything but fir, because it is a better wood.

You understand in the lumber situation that spruce does not grow like a field of wheat. You have to go back and pick it out, and build logging roads and railroads, and you cannot afford to cut all the timber off to get the select stock. You have to have your saw mills and you only get a small percentage when you saw a log.

QUESTION:—What length of time does it take for a stick of spruce, after it is cut, to be put in an airplane, as compared with a year ago?

MR. KETTERING:—Well, if the tree were right here and we sawed it down, and put it through the sawmill today, it would go to the dry kiln tomorrow and 14 days after that it could be in an airplane. The interesting thing is that in the 14 days you have a better stick of timber than air-dried spruce, which takes 23 months. You would have to order your wars in advance.

QUESTION:—What are we using for lubrication?

MR. KETTERING:—We are using mineral oil. As to wing covering, we have a cotton cloth now that is just about three times as good as any linen. One of the contributions that the United States has made is this new airplane cloth. It takes I think four and one-half times as much stress to tear it as to tear linen.



A LIBERTY MOTOR CRANKSHAFT WHICH WAS READY FOR THE MACHINE SHOP WHEN FORGED, NO RECTIFICATION OF ANY KIND BEING NEEDED, AND THE CREW THAT PERFORMED THIS UNUSUAL FEAT

HEADLAMP GLARE

IT was deemed necessary, in order that progress might be made toward the formulation of automobile headlight specifications, to conduct tests for the purpose of studying the problem, and particularly to collect numerical data bearing upon it. For the purpose of organizing and conducting these tests, the Illuminating Engineering Society Committee on Automobile Headlighting Specifications asked and received the hearty co-operation of the Lighting Division of the Standards Committee of the Society.

The results obtained in stationary tests showed very wide variations in value, due undoubtedly to different individual criteria for visibility and for glare. Evidently the average values obtained could not be accepted as necessarily applying to actual conditions on the road. In fact, common experience indicated that drivers were getting along fairly well with considerably less light on the road than the average values this test showed, and that they were enduring with a certain degree of success more severe conditions of glare than corresponded to the average in these tests. One fairly safe conclusion however seems to be that the extreme values obtained by individuals in this test ought not to be exceeded; that is, for visibility at 150 ft. certainly not less than 1000 cp. is required, and for visibility at 250 ft. not less than 1300 cp.; also that at 100 ft. the glare striking a driver's eye from an oncoming car ought not to exceed that corresponding to 850 cp.

Subsequent to this test the Committee was asked to participate in framing a proposed amendment to the New York State automobile law with a view to ameliorating conditions in that state. Accordingly, the Committee was represented at Albany. The New York State law finally passed provided in substance that automobile headlights should be so mounted, adjusted and operated as to avoid dangerous glare or dazzle, and that they should be sufficiently strong to reveal a person, vehicle or substantial object at a distance of 200 ft. ahead of the car. Moreover, the Secretary of State was empowered to promulgate uniform specifications for the testing of headlight devices through a suitable testing agency, and upon the basis of the report of such testing agency, to issue a certificate describing the device and certifying that tests had been made and that the device when properly applied complies with the provisions of the law, also prescribing the maximum candlepower to be used therewith.

ROAD TESTS

Secretary of State Hugo, then acting through Mr. G. B. Nichols, chief engineer of the state architect's office, and local representative of the Illuminating Engineering Society in Albany, requested the Committee to formulate the specifications under which headlighting devices should be tested to determine their compliance with the new state law. In the meantime the Committee had been preparing to make further road tests with moving vehicles to determine some additional data on which specifications could be based. These tests were consequently directed specifically toward the problem in hand in the case of New York State. As a basis for procedure the limiting values, as obtained in the stationary test on Pelham Parkway, were taken as indicating the probable limits beyond which the specifications could not go, and the road tests were laid out with a view to ascertaining whether the limits thus indicated were, everything considered, about the ones which should be adopted.

The question at once arose as to glare limit. Is it to be assumed that the glare limit which applies to a car at a distance of 100 ft. would apply also to a car at a greater distance? The idea finally arrived at was that it would be quite proper to allow a higher value for glare along the axis of the car, inasmuch as light along the axis would reach the eyes of an opposing driver only when he is at a considerable distance. When the cars get nearer, the drivers would naturally turn out for each other and enter the portion of the beam which lies well to the left of the axis of the cars. Therefore at a distance which represents passing position at 100 ft., the glare limit should not be over 850 cp., whereas along the axis it may be considerably higher.

As to the height at which the glare should be measured, the consideration of the height of the average driver's eye from the road was the guide. This height is about 60 in., therefore in adjusting the headlights for the road test the following points were measured: (1) The beam candlepower in the region at which the beam would strike the road at a distance of 200 ft.; (2) the candlepower along the axis and 60 in. from the ground at a distance of 100 ft.; (3) the candlepower 60 in. from the ground and 7 ft. to the left of the axis at a distance of 100 ft.

Two cars were fitted with identical equipment, and by the use of commercial devices the light was diffused or directed as required. With separate storage batteries and rheostats, the candlepower of the lamps could be adjusted to any required value. Photometers and screens were provided to aid in making and defining these adjustments.

A joint meeting with the S. A. E. Committee was held at Gedney Farm Hotel, White Plains, N. Y., on June 3, 4 and 5, with the participation of the Chairman of the Committee on Lighting Legislation. On the evenings of June 3 and 4, 1918, road tests were held. A study of the results, together with the results of other tests conducted by the Committee and by individuals on the Committee, indicated that the minimum driving light, as given by the stationary test, was about as little as could be got along with in safety on a dark road and in the absence of other light. These results indicated also what is already known, that is, with a good driving light a brighter glaring light can be endured. They showed also the utility of the plan of allowing a higher light 1 deg. above the axis directly in front of the car, inasmuch as this higher light helps very much in road illumination and is not particularly detrimental as far as glare is concerned in the region and at the distances at which it meets the eye of an oncoming driver.

SOURCE OF SPECIFICATION

Specifications for laboratory tests of fixed devices under the New York State law were then drawn up by the Committee and submitted to the Secretary of State, who held a hearing on June 25 which was largely participated in by manufacturers of headlighting devices. As a result of the consideration given to the Committee's specifications at that hearing, the secretary adopted them for the use of the state with only a few changes, of no importance from a technical point of view.

In placing the specifications before the Secretary of State an explanatory statement was submitted.

"The specifications for test and the interpretation of the intent of the New York State headlight law on which they depend are based on the following:

- (1) The general principles of illumination and of glare have been primary subjects for the study of the Illuminating Engineering Society from the time of its foundation in 1906 and on which a great many published data are available; also on the long practical experience of the Lighting Division of the Standards Committee of the Society of Automotive Engineers.
- (2) The general practice in regulatory legislation has been to restrict the light to a certain level above the road.
- (3) The considerations and data embodied in the report of the 1917 Committee on Automobile Headlamps of the Illuminating Engineering Society (a committee for the most part of entirely different personnel from the present committee).
- (4) The results of the tests held on Pelham Parkway on the night of March 5, at which time forty-nine observers of the most representative character participated.
- (5) Various minor road tests held subsequently to determine the applicability of the figures of the Pelham Parkway test to practical conditions.
- (6) The results of extensive road tests held on the evenings of June 3 and 4, 1918, under the direct auspices of this Committee in conjunction with the Lighting Division of the Standards Committee of the Society of Automotive Engineers.

COMMONSENSE BASES FOLLOWED

"The endeavor in the production of these specifications has been to provide a system of testing headlight devices under uniform conditions applicable to all such devices and equally fair to all, in such a way that the acceptability or non-acceptability of any individual device will be determined through exact measurements, as is evidently contemplated in the New York State law.

"The specifications represent a serious attempt to determine the limits within which the performance of any headlighting device must fall in order that its use shall not be clearly an infringement of the intent of the New York State law, and a menace to other users of the highway. The specifications do not represent an attempt to outline or impose an ideal system of lighting. They are frankly and avowedly influenced by the present state of the headlighting art as represented by the cars now using the highways of the State. They do not represent a theoretical solution of the headlighting problems, but are based primarily on the most practical tests which the Committee was able to devise and carry out, although it can be said in their favor that the theoretical considerations as deduced by the 1917 Committee on Automobile Headlights, bear out in a general way the conclusions here reached. They are in no sense revolutionary, and are not expected to drive from the road any meritorious device when used within proper limits. They are expected to provide a reasonable safeguard to all users of the road and to effect a gradual but permanent and considerable amelioration of conditions as they now exist.

"The tests required by the specifications are founded upon so-called practical or road tests. What they are intended to do is to provide a means whereby the equivalent of a uniform road test can be given to all devices.

"The Committee found the task of formulating these specifications very difficult and complicated. It is not sufficient to take a light out on the road and examine it by itself in order to determine whether it gives adequate driving light and whether it does or does not produce

dangerous glare or dazzle. In order to determine the latter point, the light under test must be met by observers in another car, and their judgment of the glare is to a considerable degree dependent upon the road light on the car in which they are riding. If they have a very good road light themselves, they will stand without danger a much higher degree of glare from the oncoming car. However, within such limits of variation as are to be expected from the fact that the judgment of the observers is influenced by their individual psychology, a reasonable degree of agreement was reached, after discussion of the results, that the figures given in the specifications as agreed would be the best ones in view of all the circumstances. Before adopting these, various other test data were examined, and in particular laboratory tests of a number of actual devices were made to see what their performance would be in terms of the proposed specifications.

"It is expected that with universal conformity with these specifications there will be no cars which do not have a fairly adequate driving light, and none which under the ordinary conditions of driving give a degree of glare such that other drivers cannot proceed with reasonable safety. Moreover, conformity with these specifications does not necessarily require the automobilist to spend any money on patented or other devices. By proper adjustment of his headlamps or by a simple expedient such as he can carry out himself, he will be able to conform with the requirements.

"It is believed therefore that the adoption of these specifications can work no hardship on any one really desirous of conforming with the law, and that the specifications, having emanated from an authoritative joint engineering committee, should stand."

FUTURE WORK

It was brought out in Committee discussion that the specifications issued are intended to meet existing conditions on the road, and not to serve as a guide for future practice in headlight design and operation. It is felt by some authorities that more desirable limits than those included in the specifications would be:

With the beam illuminating the road at a distance of 200 ft., 5000 to 6000 cp. minimum;

With the beam 1 deg. above the horizontal, 1200 to 3500 cp. maximum;

With the beam 1 deg. above and 4 deg. to the left, 500 to 800 cp. maximum.

In other words, in their opinion, it would be more desirable practice to increase the 200-ft. beam and to decrease the glare value as compared with the values given in the specifications.

CONTROL VERSUS FIXED DEVICE

The 1918 Committee, whose work as such is completed, also considered that the proper use of a controllable device is indicated as necessary if all the conditions of proper road lighting are to be met, and that no fixed and invariable device could meet all of these conditions. The tests indicated that controllable headlamps which are tilted down when the glare from them becomes offensive to an oncoming car are a commendable device.

Tests of Devices Under Law

Up to a recent date over fifty headlighting devices had been submitted to the Secretary of the State of New York for approval. Few devices have been absolutely rejected. This is because a device which will not be ac-

ceptable under the specifications with the candlepower of lamps with which the test was made, may be accepted with lamps of reduced candlepower. In many cases, however, in reducing the candlepower to a point where the device passes the specification, the beam candlepower is reduced perilously near the limit, so that it becomes questionable whether such devices are suitable for driving under conditions where the perception of objects on the road at any distance ahead is requisite for safety. Users of such devices will no doubt ascertain for themselves the disadvantages under which they labor and will change to others better designed for their purposes.

In the case of deflecting devices, only a few passed the test, using the full candlepower test lamps with the reflectors adjusted to give a horizontal beam. In cases where these devices did not fully comply under conditions of horizontal beam adjustment, lower maximum values than 17 to 20 cp. respectively are provided for. However, if the reflectors carrying such devices are tilted so that the beam is projected at a definite angle below the horizontal, higher candlepowers are allowed. It is expected that one effect of this will be to attract the attention of individual motorists to the necessity for making proper adjustment of their headlamps.

CORROSION PREVENTION OF AIRCRAFT METAL PARTS

AN interesting statement on preventing corrosion of aircraft metal parts has been prepared by Lieutenant H. A. Gardner, U.S.N.R.F. Some extracts dealing with the precautions that, it is said, must be observed, are given below.

IRON AND STEEL

Steel fittings on seaplanes and airships, are often subjected to great stress. If allowed to rust, they will become weak and unfit for service. It is imperative, therefore, that all such fittings, especially steel strength members, be given the best commercial treatment to prevent corrosion. Until recently, aircraft fittings made by contractors have been copper-plated. In certain instances these fittings have subsequently been plated with nickel. Some of these fittings were then painted before assembly. It is probable that better results would have been obtained if no plating had been applied, as copper and nickel give only the temporary protection that is afforded by their low-solution tension.

If two metals are placed in contact in the presence of water, a primary battery is formed and galvanic action ensues. The electropositive metal will go into solution and the electronegative metal will be unacted upon. This effect can be illustrated by placing a strip of iron in a solution of copper, when it will be found that the iron, electropositive metal in this couple, will go into solution, and the copper, electronegative, will plate out. If a strip of iron is placed in a solution of zinc, no such phenomenon will occur, zinc being electropositive to the iron. If a copper-plated fitting becomes scratched or abraded, moisture and air will be admitted. The iron, being the electropositive metal in the galvanic couple that is formed, will rapidly pass into solution. The oxygen of the air will then oxidize this solution and iron rust will be precipitated out, piling up into a spongy mass which will retain moisture that will serve to continue the corrosion.

There are listed below a number of the commonly used metals, in the order of their solution tendencies: Aluminum, zinc, iron, nickel, lead, copper, tin and antimony.

Any metal when placed in contact in the presence of water with another metal lower in the series, will tend to protect the latter metal from corrosion. A study of the series will indicate that zinc is the only commercially available metal applicable as a coating that is higher in the series than iron. This metal is therefore theoretically ideal to use as a protective coating on iron surfaces when applied in the form of galvanizing. The film of zinc produced, even when abraded, will have a marked protective influence upon the adjacent areas of bare steel.

The standard procedure of the Navy Department calls for the treatment of metal parts such as have in the past been plated with copper or nickel, to be coated with zinc. The zinc should be applied by the hot-dip method of galvanizing, the vapor method, or the electro-deposition method. In the salt spray test, after 100-hr. continuous exposure of metal coated by the three methods, practically the same resistance to corrosion has been shown. It should be remembered, how-

ever, that the hot-dip or sherardizing processes operate at a high temperature, approximately 375 to 475 deg. cent. This temperature may injuriously affect certain types of heat-treated steels or alloys, and for this reason the zinc plating process or cold galvanizing is preferred for such work.

Metal parts should be carefully inspected previous to plating, to find any defects that the plating would fill up. Subsequent to plating, the metal parts, either before or after assembly as may be decided, are painted with enamel. The purpose of the enamel is to give the metal parts a color that will be in harmony with the rest of the craft, and to provide a waterproof film that will afford protection to the zinc and lengthen its effective life. When exposed galvanized parts are not protected with paint, white oxide of zinc will appear on the surface. Removal of this by washing lowers the protective effect. For this reason it is advisable that all forms of galvanized objects exposed to sea water should be coated with varnish or enamel.

In the salt spray test referred to above, zinc-coated samples must show no rust after 100 hr. continuous exposure. This test is a comparative one, and it is believed that the results closely parallel those obtained from actual exposure over a period of several months. Steel parts that have been coated by phosphoric acid treatment or similar patented processes, or that have been coated with tin or with terne plate, show marked corrosion in the salt spray test in from 5 to 24 hr. In no instance do such treatments compare favorably with properly produced zinc coatings.

ALUMINUM

Aluminum, on account of its high-solution tendency, will corrode rapidly when exposed to the air in the presence of moisture. The corrosion around salt water is of course more rapid than in inland areas. Since aluminum is used extensively on aircraft for various purposes, including the construction of gages, speedometers, inclinometers, Venturi tubes and airship girders, it is important that the metal should be protected. When a clear finish is desired, spar varnish may be used, with subsequent baking of the metal part when convenient to give a more durable coating. Naval gray enamel may be used when a colored coating of even greater efficiency than the spar varnish is desired. On Venturi tubes it is probable that best results would be obtained by using a well-strained rather thin solution of spar varnish, since dipping of the part would be required. The dry film of such a varnish would have a thickness of approximately 0.0002 in. which is not sufficient to cause any deviation in the readings obtained through the tubes. Plating of aluminum has been proposed but found unsatisfactory. The plated coatings are non-adherent and porous. Exposure of plated aluminum sheets results in the rapid corrosion of the aluminum, which is manifested by the appearance of white aluminum hydrate oozing through the surface. It is possible, however, that some alloy of aluminum might be developed that would have a low-solution tension and thus be more resistant to corrosion and less subject to the above mentioned defects.

The Hispano-Suiza Aircraft Engine

By DONALD MCLEOD LAY

Illustrated with PHOTOGRAPHS

ALTHOUGH everyone is familiar with the names of the leading aces on the French front and with their daring exploits, comparatively few, even in the engineering fraternity, are aware that most of them drive airplanes fitted with Hispano-Suiza engines. Fonck, Guynemer, Lufbery, Nungesser and a score of others won fame fighting in Hispano-Suiza-equipped planes. Most of the American and English aces as well owe their medals of honor and also their lives to the dependable, flexible performance of this light, well-balanced power plant.

IMPORTANT FACTOR IN U. S. AIR PROGRAM

Owing to the veil of secrecy that has been thrown about the Hispano-Suiza engine in this country, the American public does not know that its importance in the air program of the United States may be characterized as second only to that of the Liberty engine. Thousands of these engines have been built in this country since the beginning of the war and the Government has awarded contracts calling for the manufacture of many thousands more.

Marc Birkigt, for many years a designer of mining machinery, was the designer of the Hispano-Suiza car, which proved serviceable on the notoriously poor Spanish roads. The four-cylinder engine used embodied a number of novel features of design. The name, of course, was derived from the nationality of the company which built the car and that of its inventor, the combination being, in English, Spanish-Swiss.

In 1906 the Hispano-Suiza chassis was exhibited at the Paris Automobile Salon, and shortly afterward a factory to build Hispano-Suiza cars on a small scale was established in the suburbs of the French capital. The company built some successful racing cars. When the war broke out the factory was turned over to the Gnome Company for the manufacture of rotary airplane engines. Birkigt busied himself in designing the prototype of the present Hispano-Suiza aircraft engine. Essentially, this consists in the coupling together in V-form of two of his four-cylinder automobile engines.

At this time leading French firms were trying to devise a fixed-type aircraft engine which would enable their aviators to overcome the advantages enjoyed by their German adversaries in the use of the highly-efficient Mercedes powerplant. Most of the French aviation engines in use at that time were of the rotary type, like the Gnome, Le Rhone and Clerget, the maximum power developed being about 90 hp.

From the beginning, the performance of the Hispano-Suiza gave every indication of success, but several months elapsed before it was given serious consideration by the

French military authorities. After Major La Garde had made a favorable report on the engine it was adopted for the French air service in December, 1915.

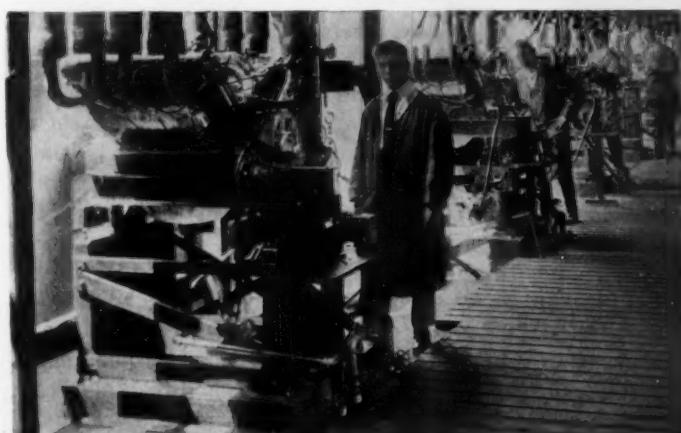
MORE POWERFUL MODELS DEVELOPED

Hispano-Suiza engines quickly came into use by the celebrated French air fighters, particularly when fitted to Spad and Nieuport planes. Their flexibility, power, ease of control, climbing ability and reliable qualities constituted an important factor in enabling the allied air forces to secure and maintain the supremacy of the air.

The type first used, Model A, 150 hp., was so successful that a more powerful engine was designed, and in December, 1916, the Model E, 180 hp., was produced. This had higher compression and a larger carburetor than the Model A, and was built to run at 300 r. p. m. faster. The Germans, beaten in speed, tried to secure advantage in greater ceiling. On that point also they were beaten, as the higher compression of the new engine decreased power loss at higher altitudes. Between 15,000 and 18,000 ft., where most of the fighting took place, performance of the engine was excellent.

In March, 1917, a 200-hp. engine was produced. This permitted an extra gun to be carried. Planes fitted with this engine were used in the battle of the Aisne and in Flanders.

In July a high-compression 200-hp. engine was built, and in a short time tests were made on the 300-hp. Hispano-Suiza engine now in service at the front.



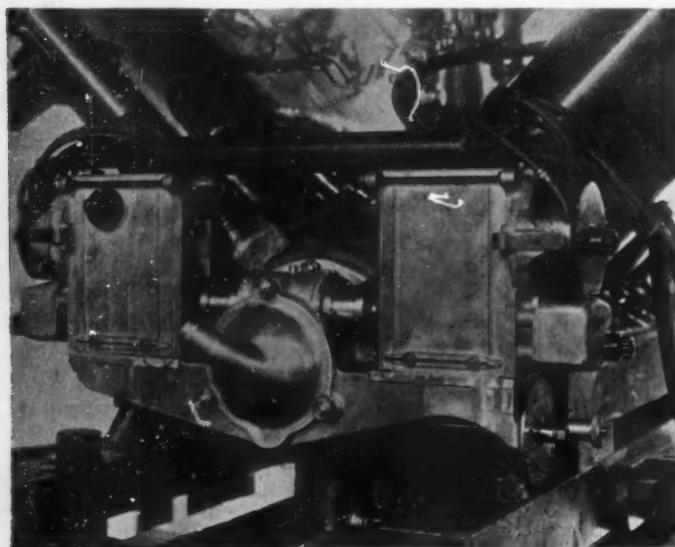
TESTING STANDS FROM WHICH OVER 700 ENGINES ARE "SHOT" EACH MONTH

For some time Hispano-Suiza engines have held the world's altitude record. The latest one to be established was made at Dayton, Ohio, Sept. 18, 1918, by a captain in the United States Army, who piloted a Bristol plane,

equipped with a 300-hp. Hispano-Suiza engine to a height of 29,200 ft. This may not have been the maximum ceiling obtainable, but the pilot was unable to endure the extremely low temperature of 26 deg. fahr. below zero. As it was, he froze his lips and four fingers. He landed 3 hr. after taking the air, at a point 200 miles from the starting point.

MECHANICAL FEATURES

The principal advantages of the Hispano-Suiza engine are its speed range, good power-weight ratio, and simplicity of design. This engine is believed to require less labor and less raw material than most other powerplants of similar capacity that are being built at the present time. As compared with the German Mercedes aviation engine, the Hispano-Suiza has approximately 500 fewer parts, the Mercedes having approximately 900 parts. The amount of raw material required to build the Hispano-Suiza engine is exactly one-third less in weight than that for a Mercedes type engine of similar capacity.



IGNITION SYSTEM LAYOUT

The Hispano-Suiza engine has eight fixed cylinders, water-cooled, arranged in two blocks of four, and set at an angle of 90 deg. The aluminum crankcase is made in two halves. The aluminum cylinder blocks incorporate water-jackets surrounding the heads of the cylinders. Each cylinder is of steel in the form of a sleeve, the outside being threaded to screw into the cylinder block. The cylinder sleeves have flanged bases for bolting to the upper half of the crankcase. The valves are located in the cylinder heads, and are operated by overhead camshafts contacting directly on disks attached to the valves, thus obviating the use of rocker arms and securing more rapid and more positive opening of the valves. Two valve springs are used for the same reason and to provide for safety in the event of one spring breaking. The camshafts are driven by bevel-gear shafts actuated from the crankshaft. Lubrication is by force feed to the bearings through the hollow crankshaft and camshafts, practically no oil being carried in the sump when a

separate oil tank is used. This is known as the dry sump system. Two magnetos are used, one on each block, with two spark-plugs to a cylinder. The plugs are located in bushings, one of which is on the inner side of the combustion chamber and the other on the outer side. The magnetos are driven by a transverse shaft, geared to the crankshaft and suitable couplings. The carburetor and the intake manifolds are situated in the V between the cylinder blocks. All working parts of the engine are enclosed.

The total output of the Hispano-Suiza engine in Europe is said to have reached recently 150 a day, of which 120 were made in seventeen French factories. One of the two companies in England producing these engines is building about ten a day.

PRODUCTION IN AMERICA

The Wright-Martin Aircraft Corporation, New Brunswick, N. J., has been building these engines for many months, and in constantly increasing quantities. Since the United States entered the war, orders were placed for several thousand American-built Hispano-Suiza engines.

The four Hispano-Suiza models manufactured in the United States are as follows:

Model A (150 hp.), which has a bore of 120 mm. (4.72 in.) and a stroke of 130 mm. (5.11 in.), and develops its rating of 150 hp. at 1450 r. p. m. at sea level. This engine was formerly used for combat, but has now been relegated to training planes.

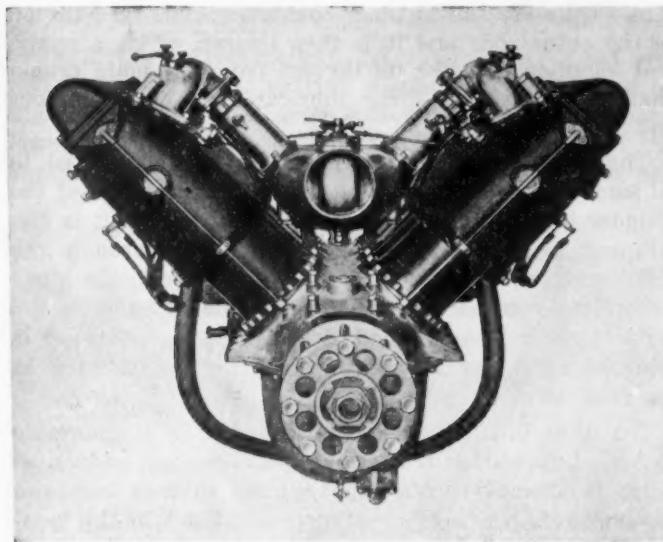
Model I (150 hp.), which is the same as Model A, except that it has the new straddle fork type of connecting-rod, the magneto drive and the timing are different, and there are some slight modifications in the piston mounting.

Model E (180 hp.), which has the same bore and stroke as Models A and I, but the compression ratio has been raised from 4.72 to 1 in the Model I to 5.33 to 1 by increasing the distance from the center of the piston-pin to the top of the piston. A larger Stromberg carburetor with 2-in. barrels, replaces the smaller one used on the Model I, to take care of the increased volume of mixture required by the higher engine speed, which is 300 r. p. m. greater than in the Model I. This engine has been widely used in English SE-5 planes for combat and general purpose work.

All three of these models are similar to the original French design, although differing in dimensions and in some details.

Model H (300 hp.) is an American design, embodying many Hispano-Suiza features. The experimental department of the Wright-Martin factory at New Brunswick has produced about twenty of these, and they have given excellent performance. They have a bore of 140 mm. (5.511 in.) and a stroke of 150 mm. (5.905 in.) and are primarily designed for combat and pursuit planes. The Model H differs from the other three types chiefly as regards the construction of the big end of the connecting-rods and the oiling system. A different type of carburetor is used.

Model I may be taken as representative of Hispano-



FRONT VIEW OF 300-Hp. HISPANO-SUIZA AIRCRAFT ENGINE

Suiza construction except for the slight differences previously mentioned. The crankshaft is of the four-throw type, 180 deg. between throws. It is made of chrome nickel steel, machined all over, and is hollow for lightness. There are four plain main bearings, bronze backed, and lined with babbitt, with one annular ball main bearing at the rear (magneto) end. The shaft extension is tapered, and has a key for the propeller-hub. The thrust for either a tractor or pusher propeller is taken by a double-row ball-thrust bearing located in the front of the crankcase. The main bearings are supported in both the upper and lower halves of the crankcase, the division of the crankcase being on the center line of the crankshaft. The faces of the two halves of the crankcase are ground to a perfect fit, no gasket being required. They are simply bolted tightly together. The lower half is very deep, providing a large oil reservoir and also stiffening the engine.

Cast aluminum pistons are used, $\frac{3}{8}$ in. thick at the head. The sides taper from $\frac{3}{8}$ in. at the top to $\frac{1}{8}$ in. at the bottom, this construction aiding in conducting heat to the cylinder walls. At the top of each piston there are four narrow rings in two grooves, and near the bottom there is one oil ring. Piston-pins are of case-hardened alloy steel, made hollow and of large diameter. They float in both sides of the pistons as well as in the upper end of the connecting-rods, the pin being held in place by a piston-pin lock-ring. The tubular connecting-rods are of heat-treated steel.

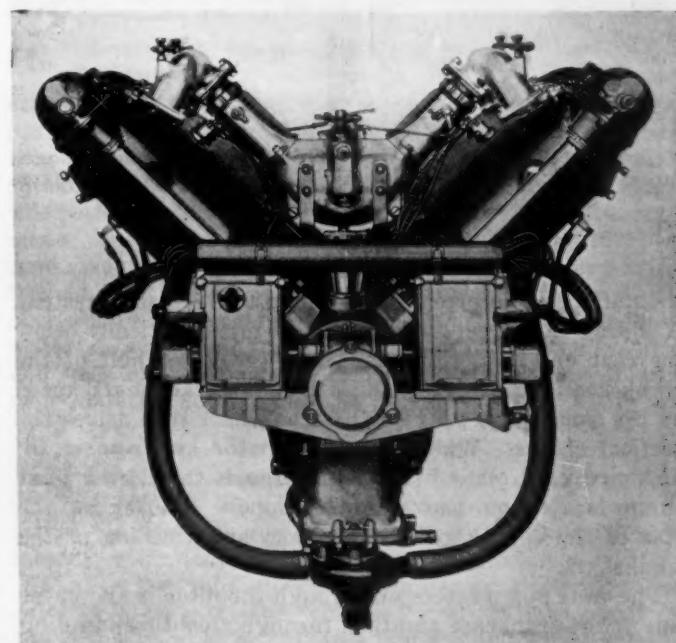
Tungsten steel valves are used. The upper end of the valve is hollow, and works in cast-iron bushings. The axes of the valves are parallel to that of the cylinder and in the same plane with this axis and that of the crankshaft. They are directly operated from a camshaft making direct contact with case-hardened, flat-headed adjusting disks screwed into the upper ends of the stems. Two concentric helical springs hold each valve to its seat, either one being sufficient to insure proper seating in case the other breaks. Clearance between the adjusting disks and the cam can be readily altered by turning the disk up or down on the threaded valve-stem. Serrated

washers, which are pressed upward by the springs, lock the adjusting disks in place, although they are easily turned by using a special wrench. The valve, locking device, and valve disk move together as a unit. The spring-retainer washer is kept from turning by tenons engaging slots in the stem.

Each of the two hollow camshafts is supported in three plain bronze bearings, and driven by two pairs of bevel gears and a shaft driven from the crankshaft. These shafts are encased in light steel tubing, and each is provided with an Oldham coupling type of joint near the middle, to permit removal of the cylinder blocks without dismantling other parts. The camshafts and the upper end of the valves and the operating disks are all enclosed in oil-tight, cast aluminum housings, which are easily removable. An air pump is mounted on the valve-gear housing, the piston being operated by one of the cams. This pump maintains pressure in the gasoline tank when the pressure system of fuel feed is used.

TWO MAGNETOS USED

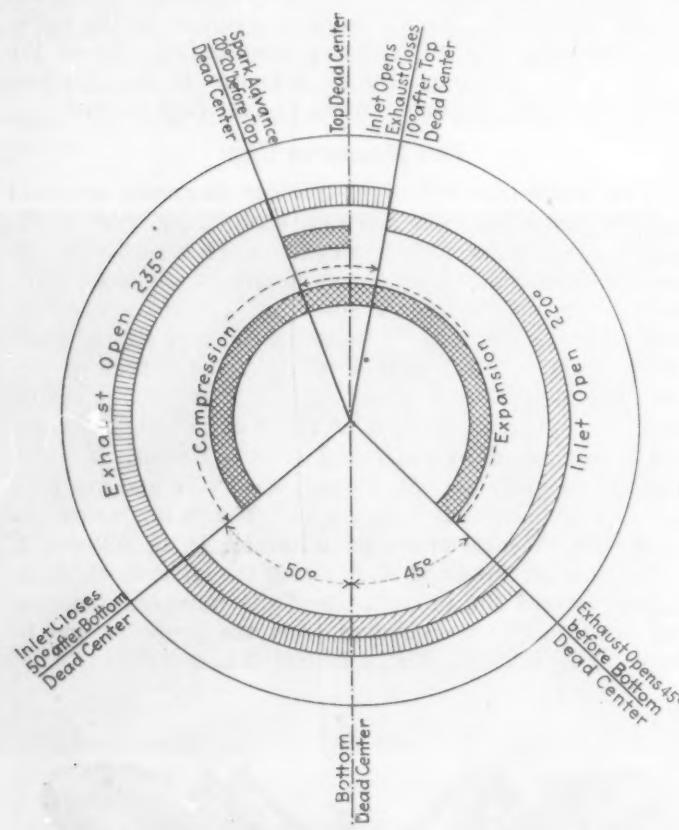
Two Dixie type 800 eight-cylinder magnetos are used on the American-built engines, each firing two spark-plugs per cylinder. Both magnetos are mounted at the rear of the crankcase on a cast aluminum support. They are driven at crankshaft speed by a transverse shaft and gear-type couplings, operated in turn by a small shaft with a spiral gear located in the center of the magneto support and driven from the end of the crankshaft. This small shaft is at right angles to the transverse magneto drive-shaft and directly beneath it. The right-hand magneto runs counter clockwise and the left-hand instrument runs clockwise. The firing order, as shown in the accompanying diagram, is as follows, *L* indicating the left-hand block and *R* the right-hand block, facing toward the propeller, and the numbers denoting the position of the cylinders from the propeller end to rear: 1 *L*, 4 *R*, 2 *L*, 3 *R*, 4 *L*, 1 *R*, 3 *L*, 2 *R*.



REAR VIEW OF 300-Hp. HISPANO-SUIZA AIRCRAFT ENGINE SHOWING INTAKE MANIFOLDS DESIGNED TO INCREASE ANGLE OF VISION

An electric or air starter can be attached by bolting a suitable bracket in place of the magneto support and oil-pump assembly. For a combination starter and long-distance wireless outfit a single-unit motor-generator system can be used. The wireless connection on the magneto has only approximately a 5-mile radius. Some engines used in pusher-type seaplanes are fitted with a geared-down hand-starting crank with a small magneto to give a hot spark at low speeds.

A single Stromberg carbureter is used, which meters and discharges the fuel by virtue of the pressure drop set up in the Venturi tubes of the carbureter. The quantity of fuel delivered can be maintained in proper proportion by the admission of air into the jet.



VALVE AND MAGNETO TIMING DIAGRAM OF HISPANO-SUIZA ENGINE, MODELS A, E AND I. THE SPARK ADVANCE IN THE MODEL E IS 25 DEG. INSTEAD OF 20 DEG. 26 MIN.

POSITIVE PRESSURE OILING

Lubrication is provided by a positive pressure system. A sliding vane eccentric pump is mounted vertically below the rear end of the crankshaft in the lower half of the crankcase. It is driven at 1.2 times crankshaft speed by the same bevel gear on the crankshaft that drives the vertical shafts. Where an oil radiator and reserve oil tank are used oil is circulated through them by a gear pump located on the magneto-support bracket at the rear of the engine and driven from an extension of the crankshaft.

The vane pump forces oil through the filter in the lower half of the crankcase and then through steel tubes leading to three of the main bearings, whence the oil enters the hollow crankshaft and is distributed to the four crank-

pins. Oil holes in the inner connecting-rods feed the oil to the outer rods and it is then thrown off as a spray, and together with the oil thrown from the main crank-shaft bearings this spray lubricates cylinders, pistons and piston-pins.

The front main bearing has a by-pass connected to oil leads which convey the oil up to the front end of the cylinder blocks to the hollow camshafts, whence it is distributed to the camshaft bearings, etc., through the hollow camshaft, the surplus escaping through the other end of the camshafts as a stream which lubricates the vertical shaft bearing and driving gears before it is returned to the crankcase through the shaft casing at the rear of the engine.

The filter in the crankcase is fitted with a removable screen. Lubrication of the cams, valve-tappets and valve-stems is effected through small holes in each cam and the camshaft bearings by other small holes in the camshafts.

CIRCULATING WATER AND GASOLINE SYSTEMS

A centrifugal pump with two discharge outlets, mounted directly below the oil-pump, circulates the cooling water. This pump is driven from the oil-pump shaft at 1.2 times the engine speed. It has a capacity of 100 liters (26.50 gal.) per min. at an engine speed of 1450 r. p. m. The capacity of the cylinder water-jackets is 18.5 liters (4.9 gal.), or by weight, 18.5 kg. (41 lb.).

The gasoline tank, if arranged for gravity feed, should be located to give 1 to 2 lb. head at the carbureter for any position of the machine in the air. For pressure feed, the pump provided on the valve-gear housing of the left-hand cylinder block may be used, a relief valve being placed in the fuel line and adjusted to maintain a pressure of not over 2 lb. at the carbureter. This valve must be designed so that it can be adjusted to compensate for differing altitudes while in flight. A hand pump is used to provide sufficient pressure for starting when a pressure system of fuel feed is employed. A vacuum-tank system can be used if desired. The vacuum is usually secured by taking a lead from the throat of a compound Venturi placed in the draft of the propeller to the main gasoline tank, a check valve being placed in the line and a branch line leading to the auxiliary fuel tank.

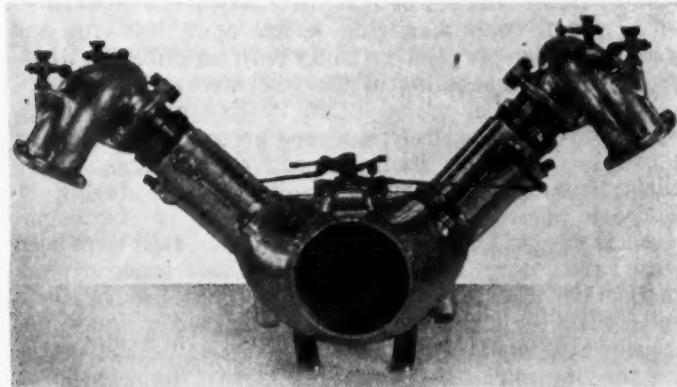
INSTALLATION OF ENGINE

In fitting the engine to a plane it should be anchored on a rigid support covered at the points of contact with fiber or sheet metal, the engine base being set flat on the support members. The camshaft and valve-gear housings are usually left exposed to facilitate disassembly. This construction enables the fuselage builder to reduce the size of the cowls. Where the engine is mounted without cowls the magnetos are protected by a leather cover.

A small drain tube is attached to a nipple at the lower part of the carbureter to carry out any gasoline that may overflow from the bowl or drip back. This tube discharges well to the rear, under the planes, as far away from the exhaust line as possible.

MECHANISM FOR FIRING MACHINE GUN

For firing a machine gun synchronized with the propeller an interrupter driving mechanism is operated by a gear pinned to another on either the left or right-hand lower vertical camshaft drive-shaft at the front of the engine. The interrupter shaft is carried on two ball



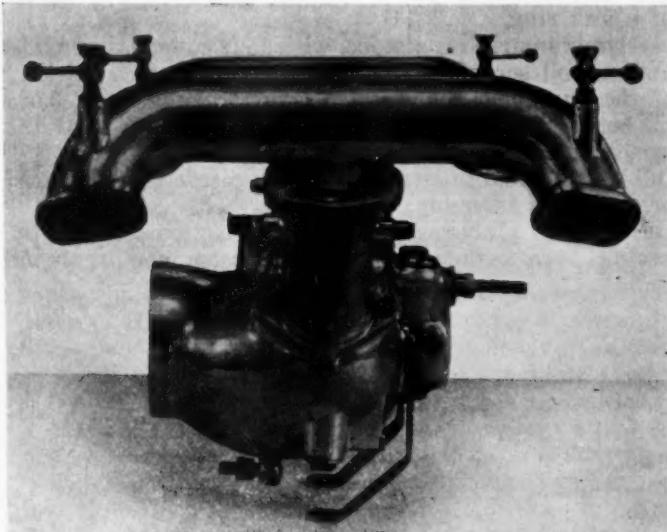
FRONT VIEW OF 300-Hp. HISPANO-SUIZA ENGINE INTAKE MANIFOLDS AND CARBURETER

bearings and is driven at crankshaft speed. A double flange connection bolts it to the driving shaft, one flange having one less bolt hole than the other. The firing mechanism is set so that the bullet, when fired from the gun, will miss the trailing edge of the propeller by $\frac{1}{2}$ in.

PRODUCTION PROBLEMS

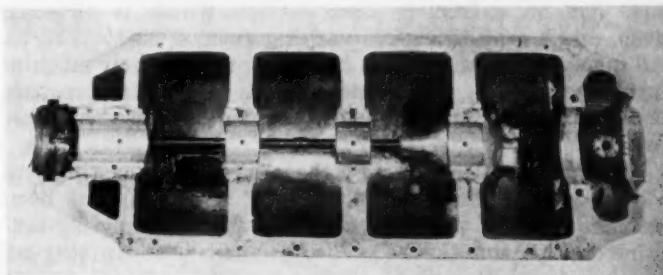
BY H. O. C. ISENBERG*

THE difficulties encountered in the production of the Hispano-Suiza engine are owing to the extreme refinement required of the various parts, not alone in the



SIDE VIEW OF 300-Hp. HISPANO-SUIZA ENGINE INTAKE MANIFOLDS AND CARBURETER

workmanship but also in the material. The attainment and maintenance of these refinements throughout the pro-

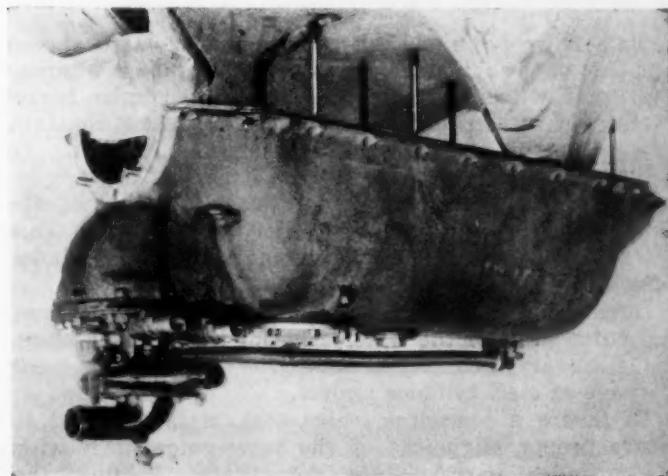


TOP VIEW OF LOWER HALF OF CRANKCASE SHOWING CRANKSHAFT BEARINGS

duction have been the hardest tasks to accomplish, as the engineering specifications for the acceptance test of the engine are such that unless the parts assembled are very nearly right, the defect will be detected on the initial or succeeding block test.

STEEL

Steel for Hispano-Suiza engine parts is purchased according to certain definite specifications resulting from foreign and American experience. All steel is first prop-



LOWER HALF OF CRANKCASE SHOWING OIL SUMP

erly heat-treated. This applies even to stock for minor parts such as bolts and nuts. Before being fabricated into raw material each heat is carefully analyzed and checked. All raw material coming into the plant is identified according to the heat of steel from which it was made. Steel forgings and bar stock are given 100 per cent visual inspection for flaws. The permissible variation of the physical and chemical properties of parts is such as to require a very careful control of the raw material, very close supervision of the heat treatments, and very exacting tests to eliminate the chance of any poor material getting into the engine.

ALUMINUM CASTINGS

All aluminum castings are cast under careful metallurgical control. A high standard of quality is maintained in the raw material by careful and intelligent inspection and checking.

By far the most difficult aluminum castings are the cylinder blocks, termed "culasse," and the lower half of the crank case. The "culasse" embodies many intricate passages, the sections of which must be of a uniform wall thickness throughout. The lower half of the crank-

*Factory manager, Wright-Martin Aircraft Corporation

case has an extremely deep section which is $12\frac{1}{2}$ in. deep, and a wall thickness varying from $5/32$ to $7/32$ in. All inspection of aluminum castings prior to their machining is exceedingly rigid, and consists of a water-pressure test for cracks, and a gasoline and compressed-air test for porosity.

The successful making of these aluminum castings on a large production basis of 200 to 300 per day has been attained only by the use of metal core and molding-machine equipment throughout combined with intelligent and constant supervision.

CYLINDER ASSEMBLY

One of the most difficult parts of the entire engine to produce is the steel-cylinder sleeve and aluminum cylinder-block assembly, with its various machining operations and sub-assemblies.

The barrels of the aluminum cylinder block are threaded individually on a vertical drill press, the tap having adjustable chasers. The length of threaded portion of cylinder barrel is $7\frac{3}{16}$ in. The steel cylinder sleeve, machined out of a hydraulic forging of 0.35 carbon steel, is threaded by a die with adjustable chasers on the last machining operation, length of thread also being $7\frac{3}{16}$ in.

To hold the pitch and the lead of cylinder barrel thread and that of the cylinder sleeve to a fixed standard whereby the latter will screw into its respective cylinder barrel freely, but without undue looseness or tightness, constant supervision of tools and workmanship is required. In addition, it is necessary to secure a perfect contact between the dome of the cylinder sleeve and that of the aluminum cylinder, to insure proper valve cooling. This contact is checked by bluing the dome of the steel cylinder sleeve.

During the succeeding operation of enameling the inner and outer walls of the waterjacket of the cylinder block, the necessary precautions must be taken to prevent warpage of steel cylinder sleeves.

To insure a concentric valve seat, it is essential to secure proper alignment of the valve-guide holes with the cylinder barrel. This necessitates holding the threaded part of the valve guide square with its shoulder, and the corresponding thread of the tapped hole in the cylinder square with the guide shoulder seat. The valve-guide hole is then finish reamed and used as a pilot bearing to bore out by means of a fly cutter its respective valve-port hole.

The cylinder assembly is now ready for grinding. Owing to the permissible variation in Brinell hardness of the steel cylinder sleeves (150 to 200 Brinell hard-

ness) and the variation of carbon content, it has been an exceedingly difficult matter to secure a uniform finish by grinding. It was found that with the use of the same wheel, the finishing of a steel cylinder sleeve of 150 Brinell hardness by grinding was totally different from that of a cylinder sleeve of 200 Brinell hardness. This difficulty was overcome by lapping each cylinder sleeve. This method has been superseded by the use of steel cylinder sleeves of 0.50 to 0.55 carbon instead of 0.35 carbon content, giving a far more uniform and excellent finish through grinding with no difficulty whatsoever in the machining of the steel sleeves.

Chromium steel valves (1.20 to 1.40 per cent chromium) are used entirely, and are ground to a full seat ($7/64$ in. wide) in their respective cylinders. These valves have given excellent results with no fusing or warpage. During the earlier try-outs on the high-compression engine, exhaust valves of tungsten steel were used with rather unsatisfactory results. Their tendency was to fuse and warp badly with the slightest leak by their valve seats, resulting in loss of power and ultimate destruction of the valve itself, and also invariably causing the burning of the piston head, with the consequent heavy scoring of the cylinder.

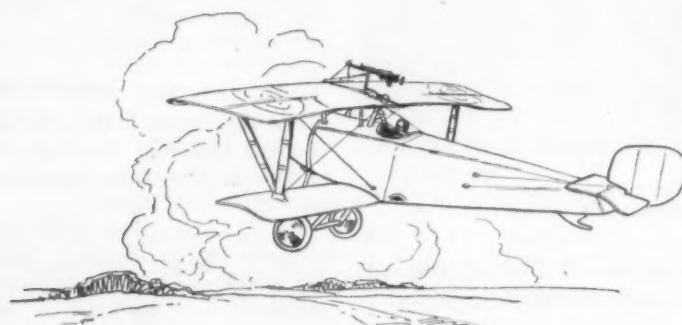
CONNECTING RODS AND PISTONS

Owing to the original French inner rod box being babbitted both inside and outside, integral with the rod, a great many replacements were required on account of cracks in babbitt after the initial block test. This construction necessitated the replacement of the entire connecting-rod instead of the bearing only. The present American type connecting-rod consists of a separate bronze box, held to the inner rod by means of four bolts, making the whole construction a very simple design. The outer rod has its bearing directly on the bronze box. The latter is babbitted on the inside for the crank-pin bearing.

The present design of wrist pin provides a floating bearing in the connecting-rod wrist-pin bushing and piston. The wrist pin is retained in position by means of a lock ring.

Aluminum, ribless pistons, with four compression rings and one oil scraper ring are used. To prevent sticking of the two upper compression rings a clearance of 0.004 in. between rings and groove is required. It is of the utmost importance that the compression rings show a full bearing, and to attain this every piston ring is lapped prior to its assembly.

Numerous problems have come up, which today, after having been satisfactorily solved, seem comparatively simple.



Washington Section Organization Meeting

AT the meeting held in the auditorium of the New Interior Building, Washington, Nov. 13, to organize a Washington Section, several interesting addresses were delivered by prominent speakers. These are given substantially in full below.

ADMIRAL D. W. TAYLOR

The first speaker was Rear-Admiral D. W. Taylor, Chief Constructor of the Navy, who said in part:

NAVY AIRPLANE DEVELOPMENT

The Bureau of Construction and Repair has to do with the hull construction of the airplane, and not primarily with motive power. We are the people who call upon the automotive engineers to help us out. We now have standard specifications for an engine. We want an engine of twice the power and half the weight, and we want it right away. Our standard specifications have been in existence for several years, and the engines we have to-day comply with them even though they were written three or four years ago.

I might say a word or two as regards our experience in the Navy with airplane development, and in this I speak as the Chief Constructor of the Navy, as well as the sole surviving member of the original Aircraft Board. When aeronautics was forced upon the attention of the Navy some five or six years ago, our policy was to deal with the airplane manufacturers, give them specifications of what we wished to accomplish, and the manufacturer who said he would accomplish it was at once given a contract. As a matter of fact, they never did accomplish it. There never was an instance, up to 1916, when airplane manufacturers ever complied with the specifications, but we kept pegging away; we accepted the planes, even if they did not come up to the specifications.

Finally, two years ago, we got a satisfactory seaplane for training purposes, and in the autumn of 1916 we gave a manufacturer a stupendous order for thirty planes, which it took him six months to deliver—and, incidentally, he fell a little short of the specifications, although he had written them himself.

At that time we had a very satisfactory engine of about 90 hp., which was afterward improved to give 100 hp., and was adequate for the purpose of a training seaplane. It was also useful for the land planes, and the Army and Navy had practically the same type of plane, one having floats and the other having wheels.

When we entered the war the best engine we had was one of about 200 hp., and we used that on a float plane, which made only moderate speed, about 80 miles, and had quite a limited endurance.

The Navy tendency was to build larger planes, to go into the flying-boat type, but it was not until the Liberty Motor was developed that we really saw the light as regards the possibilities for Navy planes. The Navy program, at the time we entered the war, simply contemplated planes for coast patrol and observation, and that kind of thing. It developed very early in the war, however, that the seaplane was very useful against the

submarine, inshore particularly. So, a little more than a year ago we undertook to establish a number of seaplane stations abroad and to fit them out with planes. The total number of stations undertaken was about ten. These have since increased to twenty, which are now in operation.

LIBERTY MOTOR

Practically the first Liberty motor flight in an actual plane was in one intended for the Navy, and it converted the rather poor plane which had been tried out with the 200 hp. engine into a very successful one, the H. S. type, which was adopted as a standard single-engine plane. The other type which was adopted about that time, to be built in quantity, was the twin-engine plane, which was being manufactured in this country for Great Britain, sent abroad and fitted abroad with British engines. We put the Liberty motor into it, and it developed into a very satisfactory twin-engine plane.

We undertook about a year ago to place an order for about 1200 or 1300 of these planes: 1157 of the single-engine type and 140 of the twin-engine type. We had great difficulty in placing the contracts, but through the Aircraft Production Board dividing up the facilities of the country between the Army and the Navy, we were able to do it. That order had not got cold before it was necessary for us to build about 800 more of the large type, and that required a big expansion of facilities, which we have met by quadrupling the capacity of the Naval Aircraft factory in Philadelphia. These planes were all built around and all depend upon the Liberty motor, and if the Liberty motor had been a failure instead of the wonderful success it is, the whole Navy program would have been a failure.

PRODUCTION

We had some delays in production, as everybody has had in all production problems in this war, but our planes began to come in May, and began to be shipped abroad, where they were assembled, and just about the time the war was over we had plenty of planes flying on the other side. As a matter of fact, for five months now the supply has been equal to the demand; planes have been manufactured about as fast as they could be absorbed both by the stations in this country and the stations abroad. We have a number of stations in this country, and since the submarine menace we have had regular patrols, something like 100,000 miles a week being covered, the planes flying over the water along the coast in the regular patrol service, in addition to training and school work.

LIGHTER-THAN-AIR CRAFT

There is another field in which we have developed what I think is also covered by the field of the S. A. E., and that is the lighter-than-air craft. We were very inexperienced in their construction when we started. Just before we went into the war we designed a small dirigible "blimp," a non-rigid, single-engine machine, and placed an order for sixteen of them. The first of those were completed in August, 1917. The kite-balloons which we undertook to build were new to this country. They had

been highly developed abroad and we simply took the foreign type and duplicated it. The single-engine blimps were fairly successful, but there was decided objection to the single-engine vessel. With the engine dead it is liable to be blown out to sea. That is not so important in work over the North Sea, because they have land on either side, but it is rather important along our coast. Fortunately, although we have done a lot of patrol work with these vessels and have lost some of them, no lives have been lost thus far.

We undertook last January to develop a larger twin-engine blimp, and those are now being completed. Perhaps some of you saw the first one a week or two ago. It flew from Akron to Washington in about 9 hr. and after alighting at Bolling Field, went on to New York that afternoon. It made New York in about 5 hr. from Washington. These twin-engine dirigibles have been quite successful. The maximum speed is between 59 and 60 miles an hour, which is almost as fast as it is possible to push a gas bag through the air. It is nothing but a gas bag filled with hydrogen. There have been some very difficult problems connected with them. The first problem was the fact that it was almost impossible to get gas-tight fabric, and when we got it, it proceeded to rot in two or three months. But those problems have all been solved and we now have, we think, a very satisfactory fabric; it is quite as good as any abroad, and better in some respects.

NAVY ORGANIZATION

Perhaps the Society might be interested in a word or two as to the organization in the Navy to handle this work. In the Army it has been a case of expanding enormously, but there has been very little change in organization in the Navy Department for the aeronautic work. The Navy Department's organization is along what I believe the sharps on those matters call functional lines as contrasted with geographical lines. There is one bureau which provides the hulls of ships, including aircraft, submarines, battleships and destroyers; another bureau provides the propulsive machinery, including that for aircraft, submarines, battleships and destroyers. With a geographical organization we would have had one bureau for battleships, one bureau for submarines, and so on. There is much to be said in favor of either type of organization. Take two of the principal railroads of the country, the Pennsylvania and the New York Central. A few years ago one was largely geographically organized and the other was largely functionally organized, and yet both were successful. So you see, either organization can be worked successfully.

Our organization in the Navy has one feature which is at once its defect and its strong point. It is an organization which requires absolutely that we have teamwork. If you do not get teamwork, the machine breaks down. At the same time, we think that if you do get teamwork—and we have not failed to get teamwork in the Navy—it is the best organization. It requires a little more care in starting an undertaking, a little more preliminary preparation, but when it gets started, the work is very much facilitated by having the same class of work handled always by the same people.

In addition to teamwork in the Navy, we pride ourselves rather on doing teamwork with the other branches of the Government; not only the Army, but, in this aeronautical development work, very largely with other branches of the Government; the Forest Service, for instance, has been of the greatest possible assistance to us.

They have developed some technical processes in connection with treatment of wood, the handling of wood, waterproof glue, etc., which have been of the greatest possible assistance. In addition to that, we have worked very closely with the Bureau of Standards. As perhaps many of you know, the Bureau of Standards, working with the Army and the Navy, took the leading part in developing the cotton fabric for airplane wings, which is distinctly superior to the linen fabric which was formerly used, and did a great deal to save the situation at a rather critical time. Enormous quantities of linen had been ordered abroad, for the purposes of Army and Navy aircraft production, and much of it was to be produced in Ireland. There were some serious difficulties arose. However, just in the nick of time, a substitute cotton fabric came along, and we are now quite independent of any other country, while the cotton fabric is we think superior to the linen.

DEVELOPMENT WORK

I have told you very little except about the production part of our program, because that is the part we have been mostly concerned with in the past year. We have not altogether neglected development, but placed orders from time to time for any planes which appeared to promise an improvement. The Curtiss Engineering Company, for instance, has completed for the Navy a plane which was actually flown at a speed of 160 miles an hour, which we think is very close to the fastest plane in the world today. We have also just completed four very large seaplanes, triple-engine boats, the N. C. 1 type, the first one of which the other day flew down from New York to Bolling Field, then went to Hampton Roads the next day, and the day after flew back to New York. It was about the size of the big Handley-Page. It has risen from the water weighing more than 22,000 lb. It has not a very high speed, only making between 80 and 90 miles an hour, but it has excellent endurance. It will not quite fly across the Atlantic, but it will fly halfway across, and perhaps if we take two, we may be able to get all the way across.

THE FUTURE

It is pretty hard for us to foresee at present what the future developments will be in the Navy, but our sea-going people feel that in addition to the work along the coast, for which aircraft is absolutely necessary now, and invaluable, the airplane must be developed and used as a regular thing with the fleet at sea, no matter where it is. Our ideal would be to have a number of planes on each ship and have them available for service at any time, just as the ship's boats are. We have not reached that ideal yet; we are a long way from it, but perhaps now that we shall not be so much occupied in production, we may with the assistance of the S. A. E. be able to approach it in the next year or two.

REMARKS of LIEUT.-COL. ORTON

Lieut.-Col. Edward Orton, Jr., assistant to Brigadier-General C. B. Duke, Chief of the Motor Transport Corps, spoke next on the work of that organization. A portion of his remarks follow:

THE MOTOR TRANSPORT CORPS

I will attempt to outline to you for a moment the situation as it appears to me, following the lines of the chairman's text; that is, whether cooperation between the S. A. E. and the Motor Transport Corps is needed and desired, and whether it will be fruitful.

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In order to gather one's ideas along this line, it is necessary for us to think back a little as to the origin of the Motor Transport, and what effect this Society has had upon its development.

The Motor Transport is technically the newest branch of the military service. That is, it was just recently organized into a distinct corps. But the work which we are now doing and for which we are now officially responsible, was carried on a couple of years ago, at the beginning of the invasion of Mexico, in another branch of the service, the Quartermaster Corps, but by many of the same men who are now controlling the Motor Transport. So that in effect, while the organization is technically a couple of months old, it is in reality about two and a half years old.

MEXICAN EXPERIENCE

At the beginning of this Mexican invasion we had no motor transport. The Government did not own as many trucks as you would find in a well equipped delivery department of a city dry goods store. At the beginning of the Mexican campaign it was necessary for us to organize hastily, buy trucks, get together personnel to operate them, and take them into a country practically without roads, over the worst kind of going and under almost impossible conditions, and do what our Army has never yet failed to do: "Deliver the message to Garcia"—and we did it.

Ten months of that kind of thing went on, and then our forces were withdrawn. In those ten months it had been necessary to keep a constant supply of new trucks coming; in view of the fact that we had started without any prearranged program, we did not have any shops, any stock of spare parts or any trained personnel; all of these things had to be created, while the active operation of carrying forward supplies went on day by day.

At the end of the period, before we had time to take stock and see what we had accomplished and what we had learned, we were precipitated into the present war. The one outstanding fact which we had learned from the Mexican trouble was the absolute and vital necessity of motor transport. The second, and not less important fact, was that standardization was necessary; that is, simplification of the program by adequate arrangements for maintaining motor transport, must be considered as the key to its successful operation.

STANDARDIZATION

There was no time to study the matter with care. Only thirty days intervened between our withdrawal from Mexico and the beginning of the present conflict. But our mind was made up that an attempt at standardization *must be begun*. The Army is not an institution for the study of mechanical engineering; it had no store of experience to which it could turn in such an emergency. We did, we think, the natural and logical and exactly the right thing, when we turned to the members of the S. A. E., the technical brain of the automotive field, and asked their help on this matter of standard designs. We asked them to consider with us this question of a standardized vehicle, or a series of such vehicles, and they attacked the problem in a way that was most gratifying. They held two or three meetings, apportioned the work, laid out the field of investigation, submitted tentative plans, and by the time that the War Department was actually ready to embark on a program of equipping the forces for overseas, this organization had

already laid the foundation for a series of standardized military vehicles.

WORK OF S. A. E. MEMBERS

The work which followed is, I think, one of the least known, but most vitally interesting stories of the preparation for war. Comparatively few people know of it. In the short period of seventy-five days the small group of officers in the Motor Transport who had knowledge of truck design, and a large group of S. A. E. members who dropped their ordinary business to come to Washington for the purpose, put on paper, produced in metal, assembled and operated the first standard American military motor vehicle. It has since demonstrated by its work that it is the best military truck in existence. Seventy-five days it took to do that! No such record has ever been made before or since.

Of course, there have been improvements, modifications, better manufacturing arrangements and things of that sort, but in effect that first stupendous effort has stood, and we believe will stand. We consider it a great tribute to the engineering skill of this association that it was possible in so short a time to design and actually produce a complete new vehicle.

So, from the standpoint of whether the Motor Transport Corps should welcome cooperation from this society, I would say there is only one answer possible. We certainly wish to cooperate! We have been benefited in the past, and we can therefore look with confidence to benefit in the future.

FUTURE DEVELOPMENT

The Motor Transport is young yet. It has not as yet more than begun to fulfill its full mission. It is a new organization and has not yet had time to fully assimilate its duties. The Army has not as yet had nearly enough time to see the various ways in which the Motor Transport is to become important and vital in its future work.

As I have stated, a very distinct step toward real standardization has been made by the consolidation of the motor vehicle work staff of the various corps which have been interested in equipping various branches of their service with motor vehicles; by the consolidation of all this work into one organization, it will now, we believe, become possible to take great steps ahead in the way of efficiency. The adaptation of the Motor Transport to work not now performed by it opens a wide field. The motorization of other branches of the service than those which are now motorized must be constantly looked forward to. We feel that while we have made a tremendous growth already we have a very large field yet ahead and unconquered. Therefore we must still look toward this Society for help. You have helped us once; we want your help again!

The most cordial relations have existed between the S. A. E. and the Motor Transport officials. I do not like to lay too much stress on the gratitude of the Motor Transport to the S. A. E., because, as some witty man said, "Gratitude is properly defined as a lively sense of favors yet to come." We are grateful, but we think that possibly the S. A. E. may be willing to admit that the Motor Transport Corps has been of reciprocal advantage to the society.

BROAD COOPERATION

It happened to be my good fortune for a few short months to work in the Engineering Division. I had the pleasure there of seeing groups of manufacturers come

together to discuss questions of the design and supply of the various constituent elements of the motor truck. It was one of the most astonishing and most enlightening and wholly delightful experiences that I have ever had, and ever expect to have. I had the supreme satisfaction of seeing groups of American manufacturers, who had apparently fought shy of each other all their lives and who seemed to have the idea that their competitors wore horns and tails and were not to be trusted in any way, come together and, under the sympathetic leadership and gentle pressure which we were able to exert, find that they were pretty good fellows all the way around and that cooperation was a pleasure as well as a patriotic duty. It is my firm conviction that there are certainly hundreds and perhaps thousands of American manufacturers today who are better friends, better manufacturers, and members of a much more closely knitted craft by reason of the fact that the necessity of war brought them together and made them willing to work together. Teamwork is what counts in this world. Teamwork is what you manufacturers did not practice till the Army made you get down to business. We have left our mark on you, for your own betterment. I think that while the S. A. E. has helped the Motor Transport, the Motor Transport has helped the S. A. E., and it has helped American manufacturers in this entire field.

From that angle I welcome very much indeed an opportunity for representatives of these organizations to get together more frequently. I can see no angle of this topic that will not lead to an improvement in existing conditions. One of the outstanding facts of the war is that Americans have quickly learned to abandon their differences and get together, and in doing so have found that friendship, affection and kindly relationship are worth more than money. I believe that this organization stands out among other American organizations as one of the best for promoting that solidarity of feeling, that kindly goodwill, which brings people together and makes them anxious to work for a common cause. It is again a source of delight to me, not only to be a member of this organization and a member of the Motor Transport Corps, but to see these two organizations linked together with ever increasing ties of mutual esteem and goodwill.

REAR-ADMIRAL C. W. DYSON

You all know that before 1914 there were very few people in this country who took the airplane seriously. The engines we had were about as unreliable as engines could be. When we could get one that could stand up for an hour's flight, we considered it phenomenal. In our acceptance tests at the navy yards there was only about one engine out of all those submitted which succeeded on the first trial in going through the 10-hr. test. So little was known of the difficulties in this art, that one noted manufacturer of this country came to us and said that he wanted to get in on a certain contract and asked to have three months in which to build an engine from original designs and submit it for the test. The contract was given to him; the engine was submitted, it was put on the stand, and in 10 min. it was a wreck.

AIRPLANE ENGINES

When the war broke out, that was the condition in which we stood. From 1914 until we entered the war, we were offered I do not know how many different types

of engines that were not good enough for the French or for the English, but Americans had gone abroad and obtained an interest in them and tried to sell them to Uncle Sam, from purely patriotic motives, of course.

We made haste slowly, encouraged our own manufacturers, and by the time the war broke out we had the Curtiss engine, which was good and reliable at that time. The Liberty engine was developed and then we had another engine, the Hispano-Suiza, which was reliable. The power had gradually been increased, so that while at the beginning of the war we had engines of 100 hp., with planes making about 90 miles, we have today planes fitted with engines giving a total of from 750 to 850 hp. and, as Admiral Taylor has told you, one plane making as high as 160 miles an hour. At the same time, the weights have gone down, so that while at the beginning of the war engines were weighing about 4 lb. per hp., today engines are weighing 2 lb. per hp., this change having been brought about by substituting steel for cast iron in the cylinders, brass and copper for steel, and using aluminum wherever practicable. The engines we have today seem fairly reliable, compared with those we had formerly, but of course the engine of the plane cannot ever be as reliable as the engine of the dirigible. While in both, reliability and low weight are very desirable, yet in the plane which has to lift itself as well as maintain speed, we have to sacrifice reliability to save in weight.

NAVY DEPARTMENT POLICY

We ourselves have done very little of the development work; we have not had time. We have depended almost entirely on the manufacturers, have told them what we wanted, and they have done their best to carry out our desires. Most of the work we have done has been in attempting to correct defects as fast as they developed; when one attempt failed, we attacked the problem again.

We have followed the same line in all our work throughout the war. In steam machinery, in submarine machinery, in the gasoline engines, we have taken the best we could find on the market, practically throwing away entirely, so far as machinery was concerned, any attempts at new development, except where previous experience had shown that the development must occur to give us reliability. It has been on this basis that the naval machinery has gone through the war so successfully. The only case that I can recall in which we departed from old types for an absolutely new one, was in the case of the Eagle boats. In the Eagles there were points of necessity to be considered which no other boats had. One of these was absolute quietness in running. We threw into the discard the ordinary turbine reduction drives, that we had been employing in our destroyers and we put in a drive that had been originated by a Baltimore firm, and which all of our critics prophesied was going to be an absolute failure. In the shop trials and in the trials of the ships, this machinery has lived up to every expectation. With the ship running 18 knots, the engine rooms are almost silent, a thing that I think has never been known before in steam machinery. There is no rumble of the gears, no vibration of the ship. All the pumps are rotary pumps. There is no noise. The value of this is readily seen when you understand that these boats are for listening duty to detect submarines when submerged.

Now, to turn to the value of this Society, my experience during the war has been that one of the most valuable things that has come to me from the war has been my association with outside engineers. My office is

full of them almost from morning till night. It has broadened my horizon, as well as that of every man in my Division who has been thrown in with these people; we have come to know the outside point of view and they have learned our point of view. We work together now better than we ever did before, and that is saying a good deal, because we have always worked well with people outside our department. The general idea outside engineers have had that naval engineers are narrow-minded has I think been dispelled. At least, we have done our very best to dispel it.

I think that the opinions of your Society here in its meetings will be of very great benefit to yourselves and to the naval service.

REMARKS OF LIEUT.-COL. W. G. WALL

After endorsing the proposal to form a Washington Section of the Society, in pointing out the importance of standardization in the automotive field, Col. Wall described the various types of tractors and other vehicles developed by the Engineering Bureau with which he is connected.

PRODUCTION OF CRUDE PETROLEUM

STATISTICS on the production and consumption of crude petroleum are collected by the United States Geological Survey. The Bureau of Mines collects reports on the monthly production and stocks on hand of petroleum products.

The Bureau's method of determining the production and the storage of refined products is to request the refiners of the country to submit individual reports each month. These reports show the amount of crude oil run to the stills, the partly refined oils rerun, and the casinghead gasoline used for blending purposes. In addition, the monthly output and the stocks on hand of the following products are given: Gasoline, kerosene, gas and fuel oils, lubricating oils, paraffin wax, petroleum, coke, asphaltum and miscellaneous oils.

There has been a gradual increase in the output of gasoline for over a year and a half.

The increase in the consumption of crude oil by refineries is as follows:

	Barrels
Daily average 1917	863,374
Daily average first seven months 1918	874,964
Increase	11,590
Daily average of July, 1918	940,991
Increase over 1917	77,617

Increased Production from Public Lands

The enactment of a law providing for the development of the oil lands of the United States would open to exploration and development the vast areas of public land in the United States and Alaska now absolutely withdrawn, thereby resulting in the discovery and development of new oil fields and deposits, and add to the oil and gas supply of the country. Another favorable result of the enactment of this legislation is that it would permit the leasing of lands now withdrawn and actually proved to contain valuable deposits of oil and gas by existing wells either upon the lands themselves or upon adjoining tracts. The fields are located principally in the States of California, Wyoming, Montana and Louisiana. The passage of such a law would permit of the further development of existing claims in withdrawn areas which have upon them one or more producing oil wells. These areas are already equipped with pipe lines and facilities for developing and transporting oil, and many of the individuals and corporations interested have equipment in the way of casing and other supplies which could be immediately utilized in the drilling of additional wells. The enactment of legislation which will, while properly protecting the public interest, stimulate and encourage the production of oil from our public lands, is important and desirable.

—*Director Van H. Manning of Bureau of Mines.*

GAS ENGINE WAR SERVICE COMMITTEE

THE War Service Committee of the Gas Engine Industry, which includes farm, stationary, portable and tractor engines, as well as accessories for gas engines, certified by the Chamber of Commerce of the United States to the War Industries Board, is constituted of H. G. Diefendorf (Chairman), 1410 G Street N. W., Washington; C. Heer, The Reliable Engine Co.; R. K. Schriber, The H. C. Doman Co.; Walter Brown, The Webster Electric Co.; L. S. Keilholtz, The Domestic Engineering Co.; C. W. Pank, Fairbanks, Morse & Co., and George D. MacVeagh, National Meter Co. H. R. Brate, the S. A. E. vice-president of Stationary Internal Com-

bustion Engineering, is executive secretary of the Committee.

The Committee took up the matter of eliminating engine sizes considered unnecessary in time of war. Formal recommendations were prepared, and a questionnaire sent to engine manufacturers. Mr. Diefendorf has been in charge of the Washington office of the Committee. A joint meeting with the war service committees of other industries will be held in Atlantic City, Dec. 4, 5 and 6, at which the priorities question will be gone over and a program of work during the reconstruction period mapped out.



Standard Engine Testing Forms

PRIOR to March, 1917, no standard engine testing forms were in existence. It is true that the various manufacturers undoubtedly had forms of their own, but no real basis existed upon which it is was possible to compare the results of tests made by manufacturers. At that time the first report of the Engine and Transmission Division was adopted by the S. A. E. By the use of the S. A. E. standardized forms it is now possible to compare directly the results obtained with different engines of various makes. The forms consist of four sheets, one of which contains rules and directions for the use of the forms and the conduct of the test, while the other three provide means for giving information regarding the engine conditions of the test and plotting curves of the results.

RULES AND DIRECTIONS FOR USE OF FORMS

SPECIFICATION SHEET

(See corresponding numbers on sheet)

(2) Piston displacement, see tables, S. A. E. Handbook, Vol. I, sheets 42-421.

(3) The compression volume is the volume occupied by the charge when the piston is at the top of the compression stroke. To measure this volume, with the piston on dead center at end of compression stroke (*i. e.*, with both valves closed) fill the compression space from a graduate containing a known volume of light oil or kerosene. Care must be taken to correct for leakage. Total volume of cylinder = piston displace-

ment + compression volume. Give compression pressure at 100 to 120 r.p.m., or at speed of standard starter.

(4) State number of cylinders cast integral, whether offset; type of cylinder head, whether water space is provided between adjacent cylinders.

(6) State whether water or air-cooled. If the former, state whether pump or thermosyphon. Note if two pumps or thermostat are used. State type of pump.

(7) Weight of piston with rings and pin should include weight of bushings, screws, or other piston-pin fastening devices in the piston. Record all weights in pounds and decimal parts thereof. In measuring length of piston and distance from center of pin to top of piston, deduct any chamfer or crown at top of piston.

(8) Specify whether rings are concentric or eccentric; give name, sketch or description of special types. If oil-ring is used, state location.

(9) In giving weight of connecting-rod, include weight of all bushings, bolts, screws, and oiling devices normally attached to the rod. For piston-pin see (7). The connecting-rod must be horizontal while the ends are being weighed, the ends being supported by knife-edges or arbors. For V-type engines, state lower end construction.

(10) Under location, state whether in connecting-rod or piston.

(12) Diameters and lengths of bearings are to be stated in order from front to rear.

(14) Describe contour of cam, *i. e.*, uniform acceleration, tangential, etc.

(15 and 16) In case of non-poppet valves, describe and give dimensions.

(17) Reciprocating parts of directly operated poppet valves include valve, valve-lifter, valve-spring retainer and lock, and half of valve-spring.

(19) To determine valve-timing, mark top and bottom dead centers on flywheel rim; also points at which each valve opens and closes, engine cold and tappets set for standard clearance. Measure with flexible steel tape the length of arcs thus marked on flywheel. Reduce to degrees. Check both top and bottom dead centers for engines with offset cylinders.

(20) Moment of inertia of the flywheel is to be given in mass (weight in pounds) and foot units. Moment of inertia is equal to the mass multiplied by the square of the radius of gyration. $I = MR^2$.

(21) The complete weight of engine should include oil, water, and all mechanically attached units necessary for normal functioning of engine, such as carburetor and its attachments, magneto, ignition distributor, generator, starting motor, fan, governor, etc. Do not include such accessories as horn, tire-pump, vacuum tank, etc. List weight of each item separately.

(24) State if heated by water or exhaust, and whether part or all of the air entering carburetor is heated.

(25) Under "general principles of operation" give description; *e. g.*: "Venturi type with single adjustable nozzle and single auxiliary airvalve with one spring"; "straight-tube type, four non-adjustable nozzles coming into operation successively as air-flow increases."

(26) By description and sketch, give general form, approximate inside diameters of different portions, and specify which, if any, parts are jacketed.

(27) In case of two systems, state which was used in test.

(29) State if spark is fixed, or if spark control is automatic or manual. Maximum spark advance and retard are to be given in degrees of crankshaft rotation.

(30) Give material of insulation, number of sparking points on electrodes.

(31) In addition to exact location in combustion chamber, state whether vertical, horizontal or inclined, and whether plug extends into combustion chamber.

(32) Give the general type of lubrication system, *e. g.*: "recirculating splash"; "force-feed and spray"; "complete force-feed." Then describe in detail action of system and course taken by oil. State oil pressures and type of pump used. State name and grade of oil used.

S. A. E. ENGINE TESTING FORMS—SPECIFICATION SHEET—B								
Name and Model	Date of Test							
Manufacturer								
(1) General Type	Cyl.							
(2) No. of Cyl.	Bar.	in., Stroke	in., Piston Displ. per Cyl.	cu. in., Total	cu. in.			
(3) Compression Vol. (V_c)	cu. in.	Total Vol. of Cyl. (V)	cu. in.	Compression Ratio = $V_c : V$	cu. in.			
Compression Pressure	lb. per sq. in.	r. p. m.						
(4) Type of Cyl. Cooling	Matt.							
(5) Type of Valves	Locality							
(6) Fitting System								
(7) Piston, Type	Wall.							
Wt. with Rings and Pin	lb.	Length	in., Distance Center of Pin to Top of Piston	in.				
(8) Piston Rings, No. per Piston	Width					in.		
(9) Connecting-Rod, Type								
Length, c. to c.	in.	Weight, Upper End	lb.	Lower End	lb.	Total	lb.	
(10) Piston-Rod Bearings, Dia.	in.	Total Length	in.	Wall.	Locality			
(11) Connecting-Rod Bearings, Dia.	in.	Length	in.	Wall.	Type			
(12) Crankshaft Bearings, Dia.	Bore.							
Material	Length.							
(13) Crankshaft Bearings, Dia.	Bore.							
Material	Length.							
(14) Type of Cam	Type of Valve-Lifter							
(15) Inlet Valves, No. per Cyl.	o.d.	in., Port Dia.	in., L.H.	in., Bore Angle	deg.			
(16) Exhaust Valves, No. per Cyl.	o.d.	in., Port Dia.	in., L.H.	in., Bore Angle	deg.			
(17) Weight of Valve-Operating Parts, Total	lb., Exhaust					lb.		
(18) Valve-Spring Tension, Total Open	lb.	Closed	lb.	Exhaust Open	lb.	Closed	lb.	
(19) Valve-Timing, Total Valve Open	deg.	Top Center, Closed		deg.	after Lower Center			
Exhaust Valve Open	deg.	Bottom Center, Closed		deg.	Top Center			
(20) Flywheel, o.d.	in., Weight	lb.				Mounts of Flywheel		
(21) Weight of Engine	lb.	Locality						
CARBURETION								
(22) Carburetor, Name and Model						Nom. Bore	in.	
(23) Specifications (Rate of mixture, etc.)								
(24) Name, Model								
(25) General Principles of Operation								
(26) Description of Intake Pipe								
IGNITION								
(27) Name and Type of System								
(28) Type of Distributor						Firing Order		
(29) Type of Breaker						Maximum Spark Advance	deg., Retard	deg.
(30) Spark-Plug, Name and Type						Size	in.	
(31) Location						Gap	in.	
LUBRICATION SYSTEM								
(32) Type and Description								

S.A.E. ENGINE TESTING FORMS

LOG SHEET—C

***Laboratory Readings.** See also Specification Sheet and Curve Sheet.

LOG SHEET AND CURVE SHEET

The Log Sheet and Curve Sheet have been designed for conveniently recording data and plotting curves covering the usual Standard Engine Tests. For special tests, these may be modified or special forms used.

GENERAL RULES AND DIRECTIONS

A complete Standard Engine Test includes the determination at different speeds of: (1) Max. hp.; (2) Fuel economy at max., at $\frac{3}{4}$, at $\frac{1}{2}$ and at $\frac{1}{4}$ max. hp. at each of the speeds; (3) Friction-hp. From these determinations, the following curves are plotted on the Curve Sheet:

- (1) Torque—r.p.m.
- (2) Max. hp.—r.p.m.
- (3) Brake m.e.p.—r.p.m.
- (4) Friction-hp.—r.p.m.
- (5) Mechanical eff.—r.p.m.
- (6) Fuel per b.h.p. per hour, max. hp. at each speed.
- (7) Fuel per b.h.p. per hour, $\frac{3}{4}$ max. hp. at each speed.
- (8) Fuel per b.h.p. per hour, $\frac{1}{2}$ max. hp. at each speed.
- (9) Fuel per b.h.p. per hour, $\frac{1}{4}$ max. hp. at each speed.
- (10) Thermal eff., max. hp. at each speed.
- (11) Thermal eff., $\frac{3}{4}$ max. hp. at each speed.
- (12) Thermal eff., $\frac{1}{2}$ max. hp. at each speed.
- (13) Thermal eff., $\frac{1}{4}$ max. hp. at each speed.

(13) Thermal eff., $\frac{1}{4}$ max. hp. at each speed.
 Emphasis is laid upon the value of the determination, in addition to the usual runs at max. hp. at each speed, of fuel consumption and thermal efficiency at each speed with the engine developing $\frac{1}{4}$, $\frac{1}{2}$ and $\frac{3}{4}$ of its max. hp. *at that speed*. Automobile engines operate a large proportion of the time on part load, and in the study of the operating characteristics of engines, these curves are of great importance. During the max. hp. run at any speed, the max. torque (or load) is deter-

mined. For runs at $\frac{3}{4}$, $\frac{1}{2}$ and $\frac{1}{4}$ max. hp. at the same speed it is only necessary to set the torque (or load) at $\frac{3}{4}$, $\frac{1}{2}$ and $\frac{1}{4}$ the maximum for this speed and make proper throttle setting for such load.

During the complete test, control of engine shall be by means of throttle and spark only. Engine adjustments shall be made for best horsepower output (*i.e.*, carburetor setting, spark-plug gaps, etc.), and in no case are such adjustments to be changed during the complete test.

to be changed during the complete test.

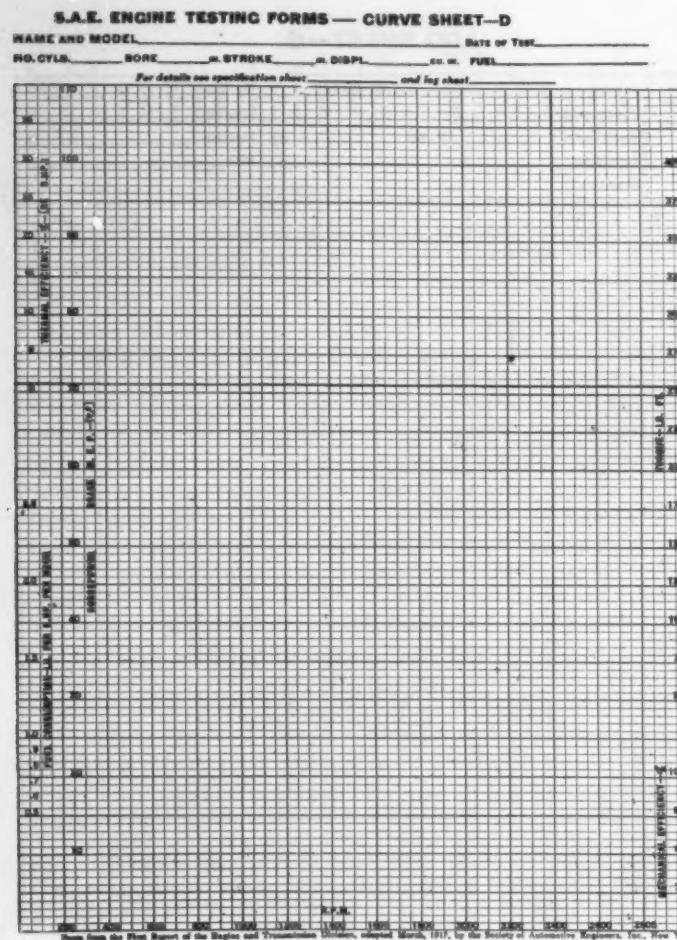
Test runs should not be made until the engine has been run-in sufficiently to show no appreciable difference in friction before and after a run of 30 min. at the speed of maximum torque with the throttle wide open.

Where test is to be made of a stock engine, all parts, accessories, lubricants, etc., must be stock. In every case, all regular equipment must be on the engine and operating (e. g., fan, generator, etc.).

Before beginning any run, the engine should be brought to a condition of sustained operation under the conditions of the run and it is imperative that in every case r.p.m., brake loads, rate of fuel consumption, cooling-water temperatures, oil temperature, air draft, etc., remain substantially constant, steady and sustained throughout the run. Flash readings and tests are unscientific and misleading.

NUMBER OF RUNS

In every test, enough runs should be taken throughout the speed range so that the points therefor when plotted will indicate clearly the shape and characteristics of the curves. For horsepower and fuel economy tests, it is recommended that runs be made at intervals of approximately 200 r.p.m. A run should be made at the lowest steady operating speed of the engine. All points from which curves are plotted are to be clearly shown on the Curve Sheet.



DURATION OF RUNS

The duration of Brake-horsepower tests shall not be less than 3 min. Where Fuel Consumption is measured, the duration of tests shall not be less than 5 min. The duration of Friction-horsepower tests shall not be less than 1 min. The above stated times are minima. In most instances it is desirable to make the runs of longer duration, and it is imperative that in every case r.p.m., brake loads, rate of fuel consumption, cooling-water temperatures, oil temperature, air draft, etc., remain substantially constant and steady throughout the run.

BALANCING DYNAMOMETER

Before any readings of Brake Load are recorded, great care should be exercised to see that the dynamometer itself is properly balanced. For the electric-cradle type of dynamometer this balancing is accomplished as follows:

The dynamometer is run idle as a motor (drawing current from the line) and a suitable counterbalance on the field frame—which should be perfectly free to turn within limits in ball bearing trunnions—is then adjusted so that the platform scales read zero. This reading should be obtained with the dynamometer rotating first in one direction and then in the other. The reaction of the armature on the field frame will exactly balance the friction of the brushes and armature bearings carried in the field frame. With the armature still rotating, check-weights (or pieces of metal having a known weight) should be hung from the knife-edge on the dynamometer arm. If the reading recorded by the platform scales is equal to the known weight applied, the dynamometer can be considered as balanced.

BRAKE LOADS

Readings for Brake Loads should be taken with accurately calibrated platform or beam scales. The connection of the dynamometer arm to these scales by means of knife-edges, calibrated spring balance and tripod or suitable linkage is recommended. Suitable counter-balances or tare loads must be accurately provided. The spring balance gives a quick

approximate reading for Brake Load; it serves to cushion the platform or beam scales from shock and vibration. During any run, the platform or beam scales are kept balanced, and the loads registered thereby must be substantially constant and steady throughout the run.

REVOLUTIONS PER MINUTE

Speed in revolutions per minute should be invariably taken from positively driven counters which engage at the beginning of the run and disengage at the end. The difference between the two readings, divided by the duration of run in minutes, then gives the true average speed. Tachometers, even though carefully calibrated, are not sufficiently reliable for r.p.m. readings. In connection with the speed counters mentioned, however, the tachometer may be used as an approximate check on average speed, also as an indicator of variations in speed before or during the run.

It is recommended that the maximum allowable variation in speed during a run shall be 50 r.p.m.

FUEL CONSUMPTION

The method recommended for measuring fuel consumption is by noting the decrease in weight of a tank from which fuel is being fed to the carburetor. The tank should be placed on sensitive platform scales at a proper level above the carburetor, and connected to the fuel-supply pipe by a short horizontal length of rubber tubing. This tubing should be very flexible and should not be drawn taut, to avoid interference with the weighing. Weighings should be made as follows:

Set the counterpoise so that scale-beam will fall just as run is started. Note the setting and the time at which the scale-beam falls. Move the counterpoise back to the next pound mark, or to such a point that it will fall just before the end of the run, and note carefully the time when beam again falls. From the difference between the two times and the two weights recorded, the fuel consumption per hour can be readily determined.

The counterpoises may be successively set back for small quantities (say $\frac{1}{4}$ or $\frac{1}{2}$ lb.) and the times noted during the progress of the run. This gives an indication of the steadiness of fuel consumption throughout the run, and in no wise interferes with the major measurements outlined in the previous paragraph.

TEMPERATURES

All temperatures are to be given in degrees fahrenheit.

A reliable glass straight-stem thermometer should be placed near the carburetor air-inlet in order to measure the temperature of the entering air. This thermometer should be read at least three times during each run, one of these times to be at beginning and one at end of run.

Thermometers should be placed also in suitable wells or sockets, one near the inlet of the pump and another as close as possible to the water-outlet of the engine. These wells or sockets should be in pipes that run full, so that water continually circulates about them. They should be filled with oil or mercury, and careful readings taken at least three times during each run, one of these times to be at beginning and one at end of run.

In order to afford a fixed basis of comparison, it is recommended that the outlet water temperature for engines be kept at 175 deg. fahr. (+ or - 5 deg.). Control of the outlet temperature can be accomplished by thermostat located in the outlet line or by external control of quantity or temperature of inlet water. Where thermostat or other cooling water regulating devices are standard upon an engine, these may be attached and operating during a test.

In every case, inlet and outlet cooling-water temperatures should remain substantially constant and steady throughout a run. It is recommended that the maximum allowable variation in cooling water temperature shall be 10 deg. fahr.

During friction-horsepower runs it is desired to obtain the mean temperature of the jacket water. If the water is pump-circulated, the average of the inlet and outlet temperatures may be taken. If thermosyphon circulation is used, the water will not circulate noticeably during a friction-horsepower run. The mean jacket-water temperature for such engines can be taken by inserting thermometers into the jacket space, the average of readings being taken. In every case of friction-horsepower test, the test must be made immediately after the corresponding brake-horsepower test, before the engine has cooled.

An air draft should be provided which approximates in amount and effect the air draft on the road with the car moving at a speed corresponding to the given engine speed.

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During friction-horsepower tests, of course, this air draft is shut off, in order not to cool the engine.

For air-cooled engines, the air draft is of the greatest importance.

FRICITION-HORSEPOWER

The approximate friction-horsepower of an engine can be measured best by means of an electric dynamometer, preferably of the cradle type. The dynamometer is used to drive the engine under test at various speeds, and the torque reaction is measured. This will be in the opposite direction to that obtaining while the engine is driving the dynamometer, so that provision must be made for measuring the torque on both sides of the dynamometer, or else suitable linkage must be provided to change the direction of the pull. The test for friction-horsepower should be made immediately after the brake-horsepower test, before the engine has cooled, in order to keep the condition of the lubricating oil

and the friction of the parts the same as during the brake-horsepower test, as nearly as possible. During this test the throttle of the engine should remain in the same position as for the corresponding brake-horsepower test. Compression-relief cocks should remain closed and all accessories, such as magneto, generator, pumps, etc., used during the brake-horsepower test, should be in operation. See notes on friction-horsepower runs under the various headings.

INDICATED-HORSEPOWER

Approximate indicated-horsepower is obtained by adding to the brake-horsepower at any given speed the friction-horsepower obtained at the same speed.

If the friction-horsepower and brake-horsepower tests are not made at exactly the same speeds, the friction-horsepower at any given speed can be obtained from the friction-horsepower curve plotted on the Curve Sheet. Tedious interpolation is thus avoided.

PRESIDENT REMINGTON OF I. A. E. ON POST-WAR CONDITIONS

PRESIDENT A. A. Remington of the Institution of Automobile Engineers of Great Britain, in addition to outlining the necessity for research affecting economical installation of radiators and comfort in suspension, made the following significant remarks as to post-war conditions so far as engineering trends and the status of the engineer are concerned.

"It can now be seen that the war will vitally affect the conditions of industry in almost every direction and it is impossible to think that when our normal industry is reorganized, I might almost say restarted, we shall revert to pre-war ideals and methods, either in connection with commerce, manufacture or design. Much has happened during the course of the war to change our ideas on those in common with other subjects, and without doubt the automobile industry will with most industries, and it is to be hoped, with the country and the world in general, ultimately reap much benefit from these changes in idea and method.

AERONAUTIC ENGINE PRACTICE

"It yet remains to be seen to what extent it will be policy for the automobile engineer to take advantage of his aeronautical engine experience. We are all aware that the aeronautical engine has a much higher mean effective pressure, higher mechanical efficiency and lower specific fuel consumption than even the most advanced pre-war automobile engine, but the requisite characteristics for the two classes of work are so different that while aeronautical engine experience can with advantage be used to some considerable degree in the automobile engine, it is difficult to say just how far results will warrant this utilization.

"But in my opinion much of the aeronautical engine experience that has been gained by our automobile engineers during the war will be found to have a profound effect on their post-war automobile production, and an examination of the extent of this effect, when such a course becomes possible, will be extremely interesting. I am looking forward to great strides in the development of automobile efficiency, using the term in its broadest sense, as a result of the war experience of British automobile engineers.

"It is probable that the examination of post-war models will, as previously referred to, show that the motor car engine has absorbed a lot of the practice that has been

developed for the immediate advantage of its sister—or shall I say child?—the aeronautical engine. It must be considered, however, that the requirements of the aeronautical engine, apart from the necessity for lightness, partake more of the character of the marine than of the motor car engine, although the development of power-weight ratio in airplanes, resulting in more rapid climb and greater altitude with its consequent reduction in atmospheric pressure, now practicable for regular flying, is bringing the conditions of operation of the airplane engine into closer analogy with the conditions that obtain for the motor car engine.

STATUS OF ENGINEER

"In the past the technical man in the engineering industry has always been subordinate to the equivalent commercial man, perhaps because it was supposed that the technical knowledge could be obtained from books, whereas so-called commercial knowledge was composed of some indefinable sort of rare instinct coupled with experience; but it is not difficult to discern that a change is taking place, and it is certain that in years to come the technical positions will cease to be subordinate in the same way as formerly. The application of more and more science to all branches of business, by increasing the necessity for scientific knowledge, will render such knowledge more general; also in future the workshop trained man who has had no real scientific training will, because of the more general existence of scientific knowledge, no longer be able to pose as scientific. The requirements of the higher positions on the scientific side of industry will necessitate the employment of many more highly trained scientists to fill them, and it is to be hoped that ultimately all management positions in our engineering industries will be filled by men possessing scientific knowledge as well as business experience.

STANDARDIZATION

"The war has been the means of causing almost every British pre-war motor car factory to be greatly enlarged, and it is therefore to be expected that after the war the output of each factory in this country will be greatly increased, and this will mean that greater standardization will be not only possible but profitable. It is therefore highly desirable that we should all, in our mutual interests, do everything we can to forward the work of standardization for the automobile industry."

War Committee of Technical Societies

ALTHOUGH the armistice has been signed and talk of peace negotiations is heard on all sides, the War Committee of Technical Societies will not cease its activities. Many of the problems which will confront the army in the immediate future are those in which this Society is interested, and for that reason Leigh M. Griffith and Herbert Chase have been appointed to represent it on the Committee, which consists of two representatives from each of the following societies besides the S. A. E.: American Society of Civil Engineers, American Institute of Electrical Engineers, American Society of Mechanical Engineers, American Institute of Mining Engineers, American Gas Institute, American Electrochemical Society, Illuminating Engineering Society, Mining and Metallurgical Society of America, American Society of Refrigerating Engineers and American Institute of Chemical Engineers.

Its aims and objects are to cooperate with the army and navy in such a way as to make available the scientific and engineering talent which it represents for war and peace purposes. To enable this Committee to function directly and continuously with the army, two liaison officers have been appointed—one from the Ordnance Department and the other from the General Staff. The chairman of the Committee has been made a member of the Naval Consulting Board and of the National Research Council, while three army officers have been appointed to liaison service with the Naval Consulting Board, thus forming something like an interlocking directorate which is equally as effective in military and naval affairs as in business affairs.

An office is maintained in the New Navy Building, Washington, D. C., to bring the Committee into close touch with the sources from which the problems likely to be submitted come, as well as to meet the wishes of the Inventions Section of the General Staff and to make the union closer between it and the War Committee. The Staff detailed a captain as liaison officer to keep it informed of war problems for which solutions were sought.

The liaison officer is charged with the duty of gathering problems from the army and submitting them to the membership of the societies for solution. Problems naturally fall into three classes: Those of a confidential nature which can be sent to specialists only, those of a character which would indicate that they should be sent to specialized groups, and those of a general nature about which any man in scientific work may have the flash of genius that will solve them.

Among the problems are a flood-lighting device for night landing on aviation fields, a method of attaching cables on airplanes so as to keep them from being broken by vibration, and improved flares to illuminate battle-fields and improved search-lights.

"If America is to take a pre-eminent place among the inventive people of the world," says Capt. Loyd N. Scott,

U. S. A., secretary of the Committee, "the scientific and educated men must come to the rescue and work on the problems that confront the Government in a serious and intelligent way." To enable these men to do this effectively, the Invention Section of the General Staff proposes from time to time to send out live concrete problems to which men with inventive talent may devote thought and study. When these have been solved the solutions should be sent to the Section at the Army War College, Washington, D. C., where military technical examiners will then pass them on to the departments interested.

One of the recent problems of interest to the automotive engineer is the design of some device or arrangement whereby a compass on an airplane can be mounted far enough away from the engine to be outside of its magnetic influence and still so arranged as to be easily read by the aviator.

In this connection it is explained that some of the new instruments designed for this work are beautiful examples of the instrument-maker's skill, but, unfortunately, when placed where the aviator can see them, are directly between him and the engine, a position which greatly affects their accuracy. If a compass could be placed near the outer end of a wing, or at the rear end of the fuselage, it would be practically outside of the magnetic influence of the engine, but at present there is no way to read a compass in either of these positions.

Another problem is a fire control gear for fixed machine guns on airplanes. With such a gear the maximum rate of fire is obtained at all speeds of the propeller and the time of impulse is advanced as the propeller speed increases so that shots at maximum speed will fall in the same position with reference to the blades of the propeller at the plane of the propeller as shots at zero speed. This also required that the gear be easily placed at any position with reference to the engine and be simple to take care of and adjust. It is obvious that if the first advantage is obtained, the second must be sacrificed, but a better combination of the two is desired than is had at present. The problem which presents itself is to devise a fire control gear which incorporates the above mentioned advantages. The solution seems to lie in an electrical system. Calculations must be based on a distance from the muzzle of the gun to the plane of the propeller of from 3 to 6 ft., a maximum propeller speed of 1600 r.p.m. and a rate of airplane machine gun fire of 1200 shots per min.

An improvement over the present method of attaching the ends of airplane cables to turnbuckles and anchorages by bending the end of a cable around a protecting liner and wrapping the overlapping end with brass wire, which is afterward soldered, is another problem in the solution of which the cooperation of the S. A. E. membership is sought.

Rural Motor Express

By S. W. FENN* (Non-Member)

METROPOLITAN SECTION PAPER

OUR work has been in cooperation with the Highways Transport Committee of the Council of National Defense and the purpose has been to bring the automobile manufacturer into this activity and through the manufacturer some 40,000 dealers distributed all over the country. Through the sales managers of truck and passenger car manufacturers we have sent form letters to dealers, telling them of this activity, and on receipt of a dealer's name from the manufacturer we have supplied him with our literature. If he has been a progressive dealer and alive to the opportunity presented by the war, he has either interested others to organize and operate a rural motor express line or he has tackled the job himself.

WORK ACCOMPLISHED IN IOWA

In the State of Iowa the International Harvester Company has been very active in this work. In and around Mason City it laid out a series of five routes, ranging from 90 to 150 miles in length and operated International trucks over these routes to demonstrate that rural motor express is a live business proposition. This was done so well that a company was organized by the leading business men of that city with a capital of \$50,000 and the lines were taken over. The International Harvester Company could never have interested these men to the point of buying its trucks and operating a rural express line without first demonstrating the practical value of the movement to the communities it served. The result has been that the business has grown to such proportions that additional capital has been subscribed and additional equipment purchased.

Recently, on one of the lines operated by this company at Mason City, two trucks, one a $\frac{3}{4}$ -ton and the other a $1\frac{1}{2}$ -ton International, made the trip from Albert Lea, Minn., to Mason City, Iowa, loaded with foodstuffs, over a new dirt road in a driving rainstorm. The distance, 42 miles, was made in 6 hr. and 40 min., at a cost of \$24.80, which covered all overhead, depreciation, interest, etc. The cost of shipment by rail would have been \$41.40.

The salesman responsible for the organization of the lines around Mason City was J. D. Eggleston of the Mason City branch of the Harvester company. I have had considerable correspondence with Governor Harding of Iowa, who had assured me of his desire to cooperate, and, as the Highways Transport Committee had not yet been formed, I laid the work of Mr. Eggleston before him. The result was that Mr. Eggleston was called before the Council of National Defense at Des Moines and the Governor commissioned him to perform a like service in every other community in the State. He will sell something around 200 trucks before other dealers commence to realize what this movement means to them, for in and around Cedar Rapids and Council Bluffs alone he has sold 150 in a work that is entirely essential to the winning of the war. Other dealers in Iowa are at last actually doing their bit, and other makes of truck are

appearing on the highways hauling the foodstuffs of the Nation.

MOVING CROPS BY MOTOR TRUCKS

I recently received a letter from Senator Cummings of Idaho in which he stated that the farmers of the Arbon Valley were about to harvest 500,000 bushels of wheat. This wheat had to be hauled 60 to 75 miles. Senator Cummings said that this was a problem that could be solved only by the motor truck, and that if the wheat was not moved the farmers would next year produce less than half of this year's crop. Interested dealers were put into communication with Mr. Turner, chairman of the Highways Transport Committee at Kimberly, and the result is that rural motor express lines will move this all-important crop.

In and around St. Louis, C. E. Lightfoot, manager, St. Louis Branch of the General Motors Company, has been very active and has been instrumental in forming six or eight different rural lines, operating Pierce-Arrow, Packard, G. M. C., Service and various other kinds of trucks. While the roads are generally good, they have a stretch of 10 miles of unpaved highway that is holding back the work. Mr. Lightfoot tells me that if the Federal Government would release a few cars of road material so that this 10-mile stretch, for which the money has been found, could be repaired, they could relieve the railroads to the extent of releasing from 75 to 100 freight cars a month for war work.

One dealer of passenger cars was induced by us to take on a truck and is now operating a rural express line out of San Bernardino, Cal., using White trucks.

DEALERS ORGANIZE RURAL LINES

Dealers have been responsible for the organization of rural lines in every state in the union, and in some states, such as South Dakota, Wyoming, Montana, Oklahoma and Arkansas, where road conditions are very bad, this work has gone ahead despite that fact.

In Tennessee, G. E. Glaser is running an interstate rural motor express line, taking in the States of Alabama and Georgia, as well as his own. He has established his system on a sound business basis and is now considering extending his activity over the entire South. He informed me that he was hauling 50 tons a day. In his first week he cleared a profit of \$800, and his operations are growing fast.

One automobile dealer in South Dakota tells us that he is operating a line from Deadwood to Sundance, Wyo. He makes the trip in about 5 hr., whereas the railroad takes from three to five days for delivery on account of extra handling and billing and rebilling.

I believe that the dealer has learned that the proper way to organize a rural line is for him to lay out the route or routes and demonstrate to the prospective buyer and operator what can be done and that there is money in it for him. That is what most dealers are doing, and they find that this method brings success. Other dealers are finding that with the curtailment of passenger-

*The author is associated with the National Automobile Chamber of Commerce

car production they will have to turn to something to keep their organizations alive until the end of the war, and they find that rural express not only does this for them, but that they can make as much profit from this activity as they can in selling cars.

Our purpose is to keep the sales manager of the manufacturing company informed as to the activities of his dealers and to bring the dealer and the State Highway Transport Committee together.

I believe that about 500 motor trucks have been sold for rural express work in the past $3\frac{1}{2}$ months. We know that over 200 have been sold for this essential work, for we have the data in our files, giving the lines and the makes and sizes of trucks employed.

ACCOMPLISHMENTS OF MOTOR EXPRESS

Rural motor express has more than made good, for it is not only inducing the farmer to practice more intensive methods, but is causing him to raise larger crops and bringing him greater profit, giving the centers of population more food at less cost and in a better and fresher condition, and creating a popular demand for better highways and more extended use of motor trucks.

Secretary Redfield of the Department of Commerce has said that our system of transportation is not a unity, but rather a trinity, and that to get a perfect service we must link up the three main mediums of transportation, the railroads, waterways and highways. Neither the railway nor the river serves the farmer. His transportation needs have been neglected, and he above all men, should have transportation, for the product of his labor is essential for the maintenance of life. This war has shown how necessary transportation for him is, and it is the duty of the motor truck manufacturer and dealer to furnish it.

If the dealer will find the route and furnish the trucks we will assist him to organize and operate, or we will help him to sell the trucks to the man who will operate.

The time is now—the need is now, and when the dealer takes advantage of the opportunity presented, he will have laid the foundation for a brighter future for himself and for a greater industry.

Supplementing his paper, Mr. Fenn presented a report of a test with motor trucks issued by the International Harvester Company. At Indianola, Iowa, there is a line operating to Des Moines, where, under tests, they were able to carry freight by motor truck for \$17.35. Hauling the same kind of load by freight over the railroad cost \$23.41. The load was handled five to six times by freight and only twice by truck. It arrived when sent by truck in a fresh condition the same day it was shipped, whereas as it did not get into Des Moines until the next night by the railroad. In another case of goods sent between Des Moines and Winterset, the cost of shipping by truck was \$5.63 and by railroad \$10.34.

THE DISCUSSION

S. P. MCMINN:—What is the method of charging for transport by truck, and what are the average charges?

MR. FENN:—The charges are based upon the physical condition of the country, the kind of truck used and the produce hauled. The only way to arrive at that is, I believe, to find the actual hauling cost, including fixed and running charges, giving the farmer a rate as reasonable as possible, so that he will be able to make a fair profit on what he produces.

I believe that the average rural motor express charges are well under the express, and in some cases lower than

the freight charges. The rural express is more efficient than freight or express, considering the time of delivery.

Not long ago we had goods shipped from Lancaster—eggs and young chickens—by the Post Office Department. A freight car and a truck were loaded at the same time; both carried an equal amount of eggs and chickens. When the truck got into New York there were only a few eggs broken and one or two chickens dead. Of the goods shipped in the freight car there were, I believe, eighteen cases of eggs broken. The Post Office Department gave out the figures. I think we cannot consider trucks efficient for long hauls, anything over 100 miles, but they are efficient for hauls of about 50 miles.

H. C. GIBSON:—Have you any data on the reduction of cost of truck operation by the use of kerosene? I have just finished conducting the *New York Herald* test run to Washington and return, in which we had about twenty-one cars running on the road; they all completed the trip, and about half of them were running on kerosene very satisfactorily, some of them reducing the cost of operation not only by the increase in mileage they made over the average of those using gasoline, but also in the fact that kerosene is on the average about 12 cents per gal.

MR. FENN:—No, I believe that has not been tried out. That is up to the manufacturer, I think. The average man who operates a rural express has not much experience in those things; he takes what is at hand, and the only thing he knows about is gasoline.

CHAIRMAN C. F. SCOTT:—I would like to ask Mr. Fenn what types and sizes of truck have been used most in the rural express; what sizes seem to be most economical for general service?

MR. FENN:—One-half to two and a half, and three tons. Anything over three tons is pretty heavy for the present condition of the roads. Where the roads are not good, light trucks will negotiate them better and with less damage to the highways. I believe that after rural express has demonstrated that it has come to stay, better highways will follow.

CHAIRMAN SCOTT:—Are a large number of these trucks converted passenger cars, like converted Fords, for example?

MR. FENN:—No, they are mostly new trucks. Lines that we hear of every day are run with new equipment.

TIRES

MR. WATSON:—I would like to ask what the experience has been in reference to pneumatic tires used on trucks. Are they using those to any great extent?

MR. FENN:—They are using pneumatic tires more or less for the light trucks, and they get over the ground very much faster, of course, and there is less wear-and-tear. Over a rough road pneumatic tires are very much more efficient than solid tires.

MR. WATSON:—Considering the efficiency of the tire, does it pay to use pneumatic tires in preference to the solid ones on, say, a 2-ton truck?

MR. FENN:—I believe it does. I think it is a better proposition, more rapid, less wear-and-tear, and less jar on the load.

N. B. POPE:—The distinction between transport by rail and transport by road is that in the case of the common carrier, that is, the railroad, the right of way is owned by the institution itself, its construction is absolutely controlled by its engineering and business departments, and the problems of traffic and of operation are unified under a single control. The highway, on the other hand, is

public property; the vehicle is in the hands of the individual owner or the corporation which is just learning the problems of operating fleets of vehicles. The situation is this: our roads have grown from accidental cow-paths to what we consider very fine roads. They are not, however, adequate to the traffic of the present day in most cases. In the few instances where highways are satisfactorily withstanding the loads of the present day they are, with few exceptions, concrete roads. The State authorities, the Federal authorities and the experts who have been enthusiastic over the highway proposition for years and years, have been doing their best to bring together the resisting qualities of the highway and the wearing qualities of the vehicle; that is to say, to strengthen the roads to a point where they will withstand the demands of modern traffic, and to stimulate the disposition of the public to pay for the kind of roads we must have.

The emergency of the war has stimulated highways transport to an unbelievable degree. The result is that the roads have broken down in many cases. A very substantial movement is under way to improve the roads, to provide funds for their development. There is an abundance of engineering ability to determine how they should be built and where they should be built. The difficulty that the roadmakers encounter, however, is that they do not know what the ultimate wheel loads of motor trucks will be. They find the truck engineers reluctant to give them any information, and the public reluctant to pay for roads which, under present circumstances, appear to be adequate to the situation. Now, that is a very large proposition. There is a great deal involved in it, and it is going to take a long time to thresh it out. Our highways today are inadequate, and the up-building of our highways will be entirely a hit-or-miss proposition until we know how big our trucks are to be built and how heavily they are to be loaded.

CHAIRMAN SCOTT:—I would like to ask whether the use of pneumatic tires on the big trucks has any direct relation to the ultimate wheel loads? Can you run a pneumatic-tired heavy truck over the road with less damage than you can a truck having solid tires?

MR. BERRY:—If you have economy in speed, you must pay for it in damaged roads. Granting that pneumatics permit greater speed and impose less strain on the truck, I believe you cannot drive the heavily loaded truck over a road at relative maximum permissible speed with any less damage to the road.

C. F. CLARKSON:—Extensive highway motor truck haulage is a development that is bound to come. We have heard for a long time about the motor truck being efficient for short hauls compared with hauls by rail. The railroads have lost a good deal of their so-called short-haul traffic for one reason or another. I believe they are not going to get that business back.

We must have roads sufficiently strong to withstand all-year traffic of motor trucks. The heavy motor truck traffic of the last several months has played havoc with the highways which succeeded the obsolete macadam road. We must have a hard-surface road, with a good foundation of concrete, and a road sufficiently wide. Anything else would be futile. Ordinary highways when subjected to severe heavy traffic become absolutely dangerous.

We know that there has been a great deal of relatively long-haul motor-truck traffic in England for some time, the so-called store-door traffic. When the war came on, an order was issued that no hauls of 25 miles or less should be made from certain cities in England by the

railroads, unless there was some real necessity for it, just as at one time here recently the express companies issued a request that nothing be delivered to them for shipment within 50 miles or such a matter, but be handled by motor truck.

RAILROAD SHORT HAUL

MR. FENN:—Robert Wright, before a meeting of the Highways Transport Committee, stated that he believed the railroads would never again care for the short haul. He is, I believe, Assistant to the Director of Railroads. He stated that it had never been very profitable to the railroads; that they look upon motor truck transportation very favorably as a relief and think it will continue after the war the same as it is today, and expand and grow.

I believe that the highways will increase in extent and quality as truck transportation over them expands.

The rural express is not in competition with the railroad at all; it is running from districts where there is no railroad, no form of modern transportation. It will be a necessity after the war as much as it is now. In fact, some parts of the rural districts have never been tapped by transportation at all. The products of the farm have been hauled to the market centers by horse-drawn carts, taking the farmer from the farm a whole day at a time, wasting time and decreasing production.

C. R. BISSELL:—I would like to ask how many days during the winter the roads are impassable in this express service?

MR. FENN:—They have not been through a winter yet, but I understand they are going to keep the main highways open this winter. The probabilities are that we will not have another winter such as the last for a good many years.

MR. POPE:—As to the relation between rural express, or short-haul express, and the work of the railroads, it has been found that the cost of stopping a freight train is something like \$6.85. Where package freight going to small communities a short distance from the terminal is concerned, the cost of stopping and restarting the train and handling the freight is a very large proportion of the cost of the haul. In such a case it is really cheaper to haul by motor truck than by rail. It is difficult to define the point at which motor truck service comes in. It is obvious that, given a sufficient volume of goods to be moved, it is much cheaper to move them over rails than over any sort of road not absolutely smooth in surface, and by a hard tire rather than a resilient one, because the latter means that you are continually mounting a hill. However, there are other considerations involved, mainly organization matters having to do with the overhead in operating a large transportation system. These make it actually cheaper in many instances to move goods by motor truck than by rail.

Another point is the distinction between rural express, interurban express and just plain motor truck haulage. That is a little hard to bring out clearly. Rural express was conceived, as Mr. Fenn has outlined, as a means of intercommunication between the farmer and his market. Until this time, the farmer has never been recognized as a source of transportation, save where bulk commodities are concerned. We recognize that wheat and corn, and other products of the farm that come into the big centers by the trainload, originate in the country and must be moved to the rail-head, but we have never recognized the farmer himself as the source of transportation which he

actually is. The reason for this has been that he has taken care of his own transportation needs.

GENESIS OF RURAL EXPRESS

Now the conception of the rural express line is that it shall go from one farm to another and collect the products which are inbound to the market, carry them in, and return to the farmer the goods which he must have, the store goods, the luxuries, the fertilizer, the implements and the various other things of which he is a buyer. As Mr. Fenn has pointed out, it takes a great deal of the farmer's time to go to market.

The little seedling rural express line running into Washington, which was developed down in the State of Maryland, and was a kind of pet project with the Highways Transport Committee, was a line developed by a farmer who was bright enough to see some years ago that he could save a great deal of time and money if he used a truck to cart his milk into the city. It was not very long before that farmer's neighbors saw that he was going by their place every day at a certain time, and they asked him to take some of their stuff in and do a few errands for them. Thus it came about that the man, whose name is Barnsley and who lives in a very small town in Maryland, came to do the entire transportation business for a group of twelve or fourteen farms. That, in the estimation of the Highways Transport Committee, is an ideal example of rural express.

The nucleus for this movement is the enterprising farmer who can organize his neighbors and start this sort of thing going. In some instances garage men have gone into it. The movement was not, however, fast enough for the Food Administration, which has become a very important factor in this matter, and so the system of promotion, which Mr. Fenn represents tonight in part, was organized.

KEROSENE AS FUEL

CHAIRMAN SCOTT:—This subject is so large from an economic standpoint that we sometimes overlook the details, and still a lot of the details are extremely interesting to the engineer, and not the least, I think, is the matter of economical movement by better use of fuels. A few minutes ago you heard Mr. Gibson say that he was working on the *New York Herald* test. I am sure that he would like to tell us in a few minutes something about that test and the results achieved in the way of operation on cheap fuels.

MR. GIBSON:—I have in my head at the present time the intricacies of twenty-one different apparatus and the performances of these—some of them on kerosene and some on gasoline—and so I cannot be very accurate.

The majority of the cars in the run were Fords, and the classes of car ranged from that to a 1911 six-cylinder Winton, along with which is classed a Packard of about the same size, one of those that weighed, with its load, some 5200 lb.; the Fords weighed about 1700 or 1800 lb., average load; some of them weighed more.

The interest, I think, lies more in those cars which were burning kerosene, although it is rather remarkable that the best performer of all, so far as mileage goes, used gasoline, with apparatus for the purpose of adding air to the mixture, inserted between the carburetor and the manifold, and operated by the foot-throttle. It took a certain quantity of air through a pipe which was laid quite close to the exhaust pipe. That car made 26 miles on a gallon.

The kerosene devices did pretty well—something like 23 miles on a gallon. Some of the kerosene devices

were extremely simple—nothing more nor less than a manifold with various passages, some for the exhaust and some for the inlet. The simplest of all of that class of apparatus performed remarkably well. It consisted of a passage around the block; a composite manifold, which was a block, the passage from the carburetor going around the outside, so that only one side of this passage was exposed to the heat of the exhaust, and then turning in, becoming an inlet manifold. It performed very well and was absolutely simple.

Another kerosene device on a Ford was one in which the mixture of kerosene vapor and some air was taken through a pipe of about 7/16 in. diameter, brought up from the jet straight, then curled around, making a helix, and brought up straight again. That rich mixture was a mixture with cold air, close to the manifold, where the division occurred, going to the two inlet parts. The curved pipe was surrounded by heat from the exhaust. That performed very well, about 20 1/2 miles on a gallon.

One thing that I noticed particularly was that nobody seemed to provide in any of the kerosene-burning devices for the removal of coke deposits that would occur in the heated passages that the kerosene went through. Twenty years ago I had experience with a gas engine using kerosene and found a tremendous lot of deposit of very hard carbon in the passages of the vaporizer. It was found necessary, after several months' use of the engines during working hours every day, to take a reamer and work hard to get that deposit out. It seems to me that any kerosene device in which the kerosene has to vaporize in passages must be provided with means for removing deposits of that character.

An interesting feature of the run was that when the kerosene cars stopped and called for kerosene it took, I believe, an average of 5 min. to persuade the garage man that kerosene, and not gasoline, was wanted. Most of the garage people had no kerosene, and those needing it had to go to the grocery store, where it was even harder to persuade them that kerosene was wanted. This shows that a great deal of education is necessary to bring people to the thought that it is possible to use kerosene in an automobile.

CHAIRMAN SCOTT:—May I ask the weight of the vehicle that did the 26 1/2 miles?

MR. GIBSON:—About 1800 lb. It was a Ford.

L. G. NILSON:—I would like to ask whether there was any difficulty in switching over from gasoline to kerosene?

MR. GIBSON:—That is very interesting. I was surprised to see how quickly they got on to kerosene and ran satisfactorily. Certain Government officials in Washington were surprised at that. They were quite skeptical. One man started his car on gasoline and I should say in about 25 sec. he performed the operation of switching over from gasoline to kerosene, and was immediately under way. The car had been standing for about an hour at that time. It was pretty much the same with most of the kerosene devices that we used. Some of them did give a nasty, smoking, gulpy exhaust, even after a minute's run, but the majority of them were splendid.

Three of the devices, I think, had double-float chambers, one for gasoline and one for kerosene. Others had separate carburetors. Those with duplicate float-chambers seemed to give the best operation.

The acceleration of the cars operating on kerosene was remarkable. One of them had an extraordinary record

for flexibility, as well as for acceleration. A Ford throttled down on kerosene to 1 mile per hr., which is almost unbelievable. Then it accelerated from that to 35 miles per hr., in about 17 sec., I believe. That is pretty good operation, pretty good flexibility.

A. M. WOLF:—I would like to ask whether it was observed that there was any difference in the operation of exhaust-heated devices throughout the conduct of the test. I believe that the exhaust heat when used should be thoroughly controlled; a manifold may get too hot, or under certain weather conditions be too cold.

MR. GIBSON:—It was admitted by several of the manufacturers of the kerosene devices that it is essential to control the amount of heat. Some of them controlled that by admitting more cold air.

FOOD ADMINISTRATION NECESSITIES

GEORGE H. PRIDE:—The rural express movement is a thing that initially does not appeal to the majority of people. To be quite frank, it did not make much of an appeal to me. It seemed remote compared with anything I had come in contact with. But it grows on you when you go into it. The way it is being built up is this: Mr. Hoover at lunch about three weeks ago made the amazing statement that he believed more than 40 per cent of all the potatoes that are raised in this country never reach the ultimate consumer. There is either loss in transit or a lot of potatoes are raised by different farmers in such small quantities that it does not pay to drive with them 15 miles to market; and so they feed them to the hogs. That applies to all the types of farm produce, with the possible exception of the hardy grains, which will stand tardy transportation and can be kept for an indefinite period. There are many by-products of the farm that at the present time are fed to the cattle, for the reason that they are produced in such small quantities each day that it is obviously disadvantageous for the farmer to hitch up his team and drive to the market with them; as, for instance, a few gallons of cream. It would cost him more to deliver the cream than it is worth, whereas through the rural express he nets about \$3.50 each day from it. That makes a good earning which has been going in times past to the pigs. It is true that the pigs grow fat but not in proportion to the dollars and cents.

The rural express movement has been picking up slowly to be sure. To my mind it is quite probable that after the war is over the use of the motor truck by the farmer—and that is what this rural express is—will present the greatest field conceivable for the automotive industry. The farmers have a marvelous capacity for absorption, and rural express will greatly increase, shall we say, not the productive wealth of the country, but the productive wealth of the country which is actually transmuted into dollars and cents. This is a community proposition. Roughly, the method of developing it is to get a list of farmers on a reasonably good road, and that means a road over which a truck can operate under ordinary conditions a reasonable number of days in the year; not necessarily a concrete road.

A questionnaire is sent out to the men within a reasonable distance of the road, asking what commodities they could sell if they had the means of getting them to the market; and whether they happen to know anybody in the neighborhood who would be suitable to run the express. Then find the man who seems best fitted for the work, and suggest that he go into it. I want to say that there has not been a single failure in that

method up to this time.

Keeping the man on the farm is a most important thing. If you can have somebody else do the aggregate delivery of several farms and keep the farmers at home there will be more production.

The farmer who has differed in his processes heretofore is being speeded up, as have all other lines of industry, wherever the motor truck is injected.

Owing to the shortage of man power, the motor truck is only one form of automotive practice; the farmers are adopting all sorts of automotive devices.

By having the rural express run by a man in their community the farmers have confidence in him, and he not only delivers material but acts as their selling and purchasing agent, exacting a small fee which they are quite content to pay.

The rural expressman develops the return load on his own hook.

DEMOBILIZATION

There is another line on which we are just about to start, which is very interesting, and that is the relation of highway transport to the reconstruction period after the war, because we are all perhaps a little optimistic as to when the war is going to end. In fact, many of the Government departments, if not all of them, are now devoting considerable thought to this. Secretary Lane, in his capacity of Secretary of the Interior, made a very interesting statement as to his idea of one very practical method of handling the demobilization. He said, "You will have millions of men returning here who have become accustomed to an outdoor life and will not want to choose indoor vocations, even if such positions were open. There will be a great change in many things we are doing now." He outlined the vision of our becoming practically a farm country. He said he thought that no land that was tillable should be permitted to remain untilled, even if the owners of it feel they are financially able to maintain it in that condition. He said furthermore that the huge timber lands in the West which had been cleared but not stumped, should be stumped, not by private enterprise but by the Government, because private enterprise is slow; that this land should then be prepared for cultivation; that the same method of procedure should be adopted to cultivate those lands in the West that are now uncultivated owing to lack of water. In other words, reclamation projects should be adopted in all the areas where possible, and should be conducted by the Government; that this land should then be subdivided into farms of reasonable size, but not too big; that the men owning them should not actually live on the farms, but in a community, as in the communal system in France, where the houses are all together, and social intercourse is enjoyed. In conjunction with this a very comprehensive highway campaign should not only be undertaken but the highways should be of such a character as to stand reasonable traffic, and that the most economic means of transportation in the way of motor power should be adopted.

APPEAL OF THE MOTOR TRUCK

The singular thing that has appealed to me throughout all the talks with these people is the fact that when you talk of highway transportation there is nothing in their mind but motor trucks; they seem to have forgotten the horse completely. Whether because the motor truck is the more potent means or has been well adver-

tised, I do not know, but when you speak of highway transportation they think of motor trucks.

VAST HIGHWAY CONSTRUCTION IN SIGHT

One of the greatest lines of development and one to be watched most carefully in the reconstruction period is highway building and the use of the highways. We are working at present on a more or less model law for limitation in weight and speed of trucks, and also on tires and licenses. I hope that the different highway departments, which have insisted they must have some standard to work to, will be able to take this standard and design their work to meet it.

After the war is over I think there will be a highway construction campaign so great that it cannot be com-

pared with anything that has occurred in the past throughout the country. The country is wild for highways.

S. A. E. PROBLEMS

CHAIRMAN SCOTT:—In closing this subject of highway transport I think we ought to fix in our minds the appeal which it carries to the Society of Automotive Engineers. The legislative problems and the road-building problems means much, but perhaps not as much in our regular routine of work as the automotive problems. We face in the future not only a great increase in the use of motor trucks, but problems of service, problems of accessories, enormous additions to the automotive industry as we know it today. These are some of the things that we should be thinking of.

ACIDITY IN BALL AND ROLLER BEARING GREASE

WITH a view to securing definite data on the effect upon the life of ball and roller bearings of a grease containing from 0.3 to 1 per cent of acidity, letters were sent to a number of bearing and lubricant manufacturers. In the letters the manufacturers were also asked to give their opinion on the relative merits of vegetable and animal oils in greases and how the viscosity of the mineral oil used affected its lubricating qualities.

The replies received were almost unanimous to the effect that lubricants containing either 0.3 per cent of free acid, or acid in any form subject to decomposition would affect the life of the bearings adversely, since it would cause pitting, with a resulting increase in the amount of friction and wear, thus defeating the purpose for which the bearing was used. Sulphuric acid was mentioned in two or three of the replies as being particularly undesirable, and for that reason oils of the asphalt type were not favored, since this acid was used in refining that type of oil and was generally present. On the other hand, one reply was that a grease containing 1 per cent of oleic acid would give just as satisfactory service as one containing 0.3 per cent, provided that was the only difference between the two. One ball bearing manufacturer stated that any grease containing more than 0.1 per cent could not be used, as the highly polished ball and ring surfaces became more or less corroded according to the percentage of acidity. It was also pointed out that a bearing operating in a grease containing an unnatural amount of acid could be recognized by more or less pronounced rust spots where no rolling action took place, while the ball and ring surfaces proper were usually dull and scratched as if from the presence of an abrasive. The percentage of chromium present in the steel, it was brought out by one manufacturer, seems

to counteract the effects of the acid in the grease to some extent, high-chromium steels corroding much less in the same length of time than those having a low-chromium content.

Mineral oils were almost unanimously recommended as bearing lubricants, the objection to vegetable oil being its tendency to dry or oxidize and the decomposition of the animal oils. One of the replies indicated that a lime soap grease with either animal or vegetable oils was satisfactory, while a soda soap grease with animal oil was better than a soda soap vegetable grease. One lubricant manufacturer recommended a combination of all three oils. One of the bearing manufacturers was in favor of the grease made from mineral oil thoroughly saponified by either lime or soda soap. Freedom from foreign substances such as graphite, cork, etc., was emphasized by another. It was also pointed out in this connection the objection to the former was that while the addition of graphite to a grease was valuable in the bearing of the plain type, it acted as an abrasive with ball bearings.

The replies did not contain much information on the subject of viscosity of mineral oil, but where this question was answered the consensus of opinion was that the viscosity depends entirely upon the conditions encountered in service. One manufacturer stated that an oil of low viscosity should be used for high speeds and light loads, while where the speed is slow and the load heavy a highly viscous oil or grease could be employed. Another bearing manufacturer stated that he preferred oils which clung to the bearings, since if the oil was too hard it would not follow the bearings but would pack up in the spaces between the cage housings, while oil that was too soft was difficult to retain.



Current Standardization Program

WHILE a number of important routine engineering standards have been established, a number of others are awaiting action by the various Divisions of the Standards Committee. The brief résumé of the status of this work is presented below:

AERONAUTICS

Practically all of the subjects mentioned in the November JOURNAL still remain to be acted upon. It is planned to hold a meeting of the Aeronautic Division at which some action, it is expected, will be taken before the meeting of the Society in January.

BALL AND ROLLER BEARINGS

Meetings looking to the establishment of a taper roller bearings standard list of sizes were held on Oct. 23 and Nov. 6. At the first of these it was pointed out that the establishment of such a standard would facilitate service to customers, as well as reduce the cost to them, and further would simplify manufacturing and effect certain economies in production. At the latter meeting it was explained that it was not the intention to attempt immediate reduction of the list to practice, but rather to propose a standard to be published and distributed to purchasing agents and designing engineers. The change will take some time and do away with many sizes that will become unnecessary, but those special sizes required by the trade will not necessarily be eliminated. It was decided that two series of roller bearings approximating the 200 and 300 series of ball bearings should be proposed for standard. Another meeting on the whole subject was held in New York on Nov. 20.

ELECTRICAL EQUIPMENT DIVISION

A meeting of this Division will be held soon. It is expected that the subjects of sleeve-type generator mountings and sleeve-type starting motor mountings, upon which preliminary work has been done, will be completed at that meeting.

ENGINE DIVISION

The dimensions for bracket generator mountings which were recommended by the Electrical Equipment Division in June will be completed when the Engine Division establishes the dimensions and definite location of the pad cast on the engine to carry the generator bracket mounting. Work on dimensions for engine support arms or general engine mounting dimensions for cars will be proceeded with at a meeting of this Division which has been called for an early date.

MISCELLANEOUS DIVISION

At the meeting of this Division held on Nov. 19, flex-

ible tubing dimensions for hot-air intakes and ball-and-socket joints for carburetor and magneto controls were considered.

The question of machine screw nut standards was taken up. A meeting of manufacturers of nuts was held on the same day, the members of the S. A. E. Miscellaneous division and of the Committee on the Standardization of Machine Screw Nuts of the American Society of Mechanical Engineers participating. A joint meeting of the Miscellaneous Division and of the A. S. M. E. Committee was held later in the day.

A number of other subjects were considered by the Miscellaneous Division.

SPRINGS DIVISION

Following the meeting of this Division in Washington on Oct. 21, the manufacturers of springs were circularized to ascertain if the finishes recommended were acceptable. The majority of the replies received at the time of going to press favor the finishes proposed.

STATIONARY AND FARM ENGINE DIVISION

The work of this Division includes the adoption of the National Gas-Engine Association Standards to S. A. E. work, the adaptability of S. A. E. Engine Testing Forms to the work of this Division and the approval of various existing S. A. E. Standards and Recommended Practices in this field. Other matters to be considered later include the simplification of engine sizes according to horsepower ratings, voltage and capacity ratings for farm lighting outfits, the standardization of mounting dimensions for engines mounted on portable trucks, and crank-shaft diameters and extensions for pulleys.

TIRE AND RIM DIVISION

It is planned to hold a meeting of this Division as soon as possible at which it is hoped important subjects, such as solid tire sizes, solid tire sections and contours, and base bands for solid tires can be definitely reported. There are also extensions or revisions of present standards to be considered.

TRANSMISSION DIVISION

A meeting of this Division has been scheduled the second week in December to consider universal joint connections, transmission drive for speedometers, transmission mounting for tire pumps, and gear shifter forks and grooves.

Several of the Divisions will hold meetings within the closing weeks of the year, so that reports can be made by them at the meetings of the Standards Committee and of the Society in January.

Activities of S. A. E. Sections

AT the October meeting of the Metropolitan Section the announcement was made that, through the courtesy of Mr. George H. Houston, vice-president of the Wright-Martin Aircraft Corporation and vice-president of the Society, arrangements had been made for an inspection trip by the members of the Section to the New Brunswick plant. That this opportunity of seeing the Hispano-Suiza engine under production was greatly appreciated is indicated by the fact that over 200 members signified their intention of attending; thus necessitating the division of the party into two groups, the first making the trip to New Brunswick, Nov. 2. Arrangements have been made for the second group to inspect the Long Island City plant, Dec. 7. At this plant the 300-hp. high-compression Hispano-Suiza engines are being produced.

At the New Brunswick plant the members were divided into groups of eight or nine and conducted through the various departments by engineers connected with the company.

After the inspection trip the party motored to a hotel for luncheon as guests of the Wright-Martin Corporation. The following addressed the members at the luncheon: H. M. Vrane, vice-president and chief engineer; H. O. C. Isenberg, assistant factory manager, and Guy W. Vaughan. Mr. Crane brought out the point that the operation of the Wright-Martin plant in full production was the result of a vast amount of work which at other times would have meant ten or fifteen years' development, and that the work of the past year had been one of transition from one kind of work to another, as in many other plants throughout the country. He cited the realization of quantity production of an aviation engine of 2 lb. per hp. weight. This result had been brought about, according to Mr. Crane, by a combination of design, workmanship and infinite attention to details, the strange part being that the engine was no harder to build than an engine weighing 10 to 15 lb. per hp.

Mr. Crane stated that in his opinion the aviation engine situation has not reached the point where there is any "one" engine, but that each type has a distinct purpose of its own. The general designs are, however, similar. He paid a tribute to the foundry engineering department which had made possible much of the splendid results obtained, for in aviation engine work much depends on the proper molding of intricate aluminum parts.

Mr. Isenberg spoke of the difficulties encountered and overcome, such as making babbitt adhere to the steel shell of the connecting-rod. He commended the Government inspectors highly, attributing much of the successful development of the plant to them. In speaking of the future plans of the company, Mr. Isenberg said that the building of aviation engines would continue, although the quantity turned out would be much less than at present.

The December meeting of the Metropolitan Section which will be held on the eleventh will be a "British Night." F. Leigh Martineau of the Institution of Automobile Engineers of Great Britain will address the meeting, his subject being "Hydraulic Transmission." Short

talks will be given by members of the British War Mission and some of the latest war films will be shown.

The meeting of the Minneapolis Section which was scheduled for Nov. 13 was cancelled on account of the epidemic of Spanish influenza. The next meeting will be held on Dec. 4 and the subject to be discussed will be "Tractor Drawbar Implements, Their Characteristics and Hitches."

A meeting to organize a new Section of the Society was held in the auditorium of the New Interior Building, Washington, Nov. 13. Over 300 persons, of whom about one-half were members of the Society, attended the meeting, which was considered most successful from every standpoint.

The following officers addressed the meeting: Rear-Admiral D. W. Taylor, Bureau of Construction and Repair, U. S. N.; Lieut.-Col. Edward Orton, Jr., representing Brigadier General C. B. Drake, Motor Transport Corps, U. S. A.; Rear Admiral C. W. Dyson, Bureau of Steam Engineering, U. S. N.; Lieut.-Col. W. G. Wall, Ordnance Engineering Bureau, U. S. A., and Lieut.-Col. T. G. Gallagher, representing Major-General Kenly, Bureau of Military Aeronautics, U. S. A. Extracts from these addresses appear elsewhere in this issue.

Herbert Chase, assistant secretary of the Society and chairman of the temporary committee on arrangements, presided at the meeting, which was opened with motion pictures on automotive war subjects.

In explaining the reasons for the meeting, the chairman said: For over a year the officers of the Society have had before them the suggestion that there be formed in Washington a Section of the Society similar to the local organizations in several cities of the country. Until recently the consensus of opinion has been that our members here were too busily engaged in war work to organize and carry on a local branch. Within the past few weeks many members of the Society have signified a desire to participate in and support the activities of a Washington Section, and a temporary committee was appointed to make arrangements for a meeting in which the matter could be fully discussed.

The success of any section organization that may be formed here will unquestionably depend in large part upon the cooperation of the various Government departments engaged in automotive engineering work. For this and other reasons it has seemed desirable to invite to the meeting the heads of these departments, in order that they may tell us briefly of the automotive engineering work they are carrying on, and give us the benefit of their views as to the desirability of our organizing a section here, thus bringing together Government and other engineers engaged in the solution of automotive engineering problems. We hope, therefore, that each of the guests who are to speak to us this evening will frankly express his views in this matter, telling us whether he thinks occasional meetings such as a Section might hold here would be directly or indirectly beneficial to the Government.

We are fortunate in having with us the heads of several Government Bureaus intimately concerned in the

design, construction and operation of all types of automotive apparatus.

It was explained further that if any of the speakers believed that the Society could be instrumental in solving some of the problems before their respective departments, suggestions to this effect would meet with a ready response.

At the conclusion of the addresses the members who attended the meeting voted unanimously to adopt a petition requesting the Sections Committee to recommend to the Council favorable action looking toward the formation of a Washington Section of the Society composed of members resident in the District of Columbia, Maryland and Virginia.

The following temporary officers were elected: Chairman, Col. James W. Furlow; Vice-chairman, Orrel A. Parker; Secretary, Herbert Chase, and Treasurer, A. B. Cumner.

Dec. 11 was mentioned as the probable date for the next meeting. A formal announcement of the subject to be considered will be made in the near future.

The November meeting of the Detroit Section was held

on the 29th at the Hotel Pontchartrain. Two moving pictures entitled, "The Process of Manufacture of the Liberty Motor" and "Aircraft Warfare" were shown, followed by a lecture on "The War In the Air," by G. Douglas Wardrop who has recently returned from France. The lecture dealt with the various war phases of aviation based upon Mr. Wardrop's observations on the Western Front and was illustrated by numerous lantern slides and motion pictures.

At the meeting of the Mid-West Section held at the Lexington Hotel, Chicago, on Nov. 8, a paper on Fuel and Lubrication Tests of the Buda Four-Cylinder Tractor Type Engine was presented by P. J. Dasey, sales and research engineer of the Buda Co. This meeting was originally scheduled for Oct. 18, but was postponed on account of the influenza.

A meeting of the Indiana Section was held on Nov. 29.

The November meeting of the Cleveland Section was held in the Electrical League rooms, Hotel Statler, on the 26th. R. W. Cunningham delivered an address on "Petroleum Refining."

PERSONAL NOTES OF THE MEMBERS

E. G. Anderson has been made advertising manager of the American Bronze Corporation, Berwyn, Pa. He has been sales manager of the same corporation for some time past.

Bernhard M. Beskow, formerly vice-president of the Commercial Tractor Company, Glens Falls, N. Y., has retired from the company and returned to the practice of his profession, civil and mechanical engineering, in Ormond, Fla.

Emil J. Beuret, formerly salesman in the Packard Motor Car Company of Detroit and stationed in Paterson, N. J., is now vice-president of Beuret & Company, Inc., New York City.

F. E. Blanchard, mechanical draftsman in the Railways Materials Company, Toledo, has taken the position of checker in the experimental department, airplane division, of the Fisher Body Corporation, Detroit.

Clement Booth, until recently engineer in the Standard Roller Bearing Company, Philadelphia, is now with the Hale & Kilburn Corporation as production engineer.

A. L. Clayden, engineering editor of *The Automobile*, has become consulting engineer in the Wright-Martin Aircraft Corporation, New Brunswick, N. J.

W. H. Conant has resigned as division manager of the Gould Storage Battery Company, Detroit, and is now with the Prismolite Company, Columbus, Ohio.

William M. Corse, manager of the bronze department, Titanium Bronze Company, Inc., has left Niagara Falls for Mansfield, Ohio, where he has taken the position of manufacturing engineer for the Ohio Brass Company.

C. L. Coughlin is now secretary and general manager of the Ladish Drop Forge Company, Cudahy, Wis. He was formerly with the Briggs & Stratton Company, Milwaukee.

A. W. Dietzel has left the Waukesha Motor Company and is now superintendent of the I. B. Rowell Company, also in Waukesha.

C. H. Dunlap, vice-president and sales manager of E. A. Nelson Motor Car Company, Detroit, is also supervising the Motor Transport Corps training with the Committee on Education and Special Training in Valparaiso, Ind.

R. O. Gill, works manager of the Dayton-Wright Airplane Company, has left to go with the Packard Motor Car Company in Detroit.

Carl R. Hennicke, assistant engineer in the Lippard-Stewart Motor Car Company, has gone over to the Atterbury Motor Car Company, also in Buffalo, as layout draftsman.

Charles E. Heywood has left the engineering department of the Boston Bailey Meter Company for the standards department of the S. A. E. in New York City.

H. O. C. Isenberg, formerly assistant factory manager of New Brunswick, N. J., plant of the Wright-Martin Aircraft Corporation, has been appointed factory manager of that plant.

Horace A. McMillan, formerly draftsman in the Chevrolet Motor Company, New York City, is now doing tractor designing for Smith, Hinchman & Grills in Detroit.

W. H. Miller, consulting engineer for the Flexible Armored Hose Company in Buffalo, has been made district representative of the Garford Motor Truck Company, Lima, Ohio, and is stationed in Kansas City.

Eddie Molloy, until recently aeronautical engineer for the Loening Corporation, now holds the same position in the Standard Aero Corporation of New York.

Ernesto Ornelas has left the position of assistant processing engineer in the Bridgeport Brass Company, Bridgeport, Conn., and is established as a mechanical engineer in Golden, Colo.

Jean Peters, formerly traveling sales representative for the Willys-Overland, Inc., Toledo, is now stationed in the Denver office of the western division of the Garford Motor Truck Company of Lima, Ohio.

Carl D. Peterson, until recently chief engineer and factory manager of the Lippard-Stewart Motor Car Company, Buffalo, has accepted a position as chief engineer and production manager in the Koehler Motors Corporation, Newark, N. J.

V. W. Phillips has established a battery service station with T. L. Jones & Company in Arnold, Neb. Mr. Phillips was formerly in Chicago.

W. C. Rands is now president of the Motor Products Corporation, Detroit.

Harry Roettinger, still representing the Standard Parts Company of Cleveland, has left the Detroit for the Cleveland office.

N. G. Rost, general sales manager of the Duesenberg Motors Corporation, is abroad as a joint representative of the Bureau of Aircraft Production and the Duesenberg corporation, in connection with the sixteen-cylinder 500-hp. Bugatti airplane motor which the latter organization developed and has been producing for the Government.

A. L. Shaw, until recently in the purchasing department of the Sumter Electrical Works in Sumter, S. C., is now with the Splitdorf Electrical Company, Newark, N. J.

J. H. Sheats, experimental engineer, is now doing research work for the Dayton Metal Products Company. He was until recently with the Dayton-Wright Airplane Company.

PERCY WHEELER TRACY died of pneumonia at the New Emergency Hospital in Washington, D. C., on Oct. 30, after an illness of eleven days.

Mr. Tracy had been a member of the Society for about two years. He was born in 1879. His work as a student in the scientific course was completed at the University of Wisconsin in 1899, after which he followed his unmistakable bent and specialized in automobile factory work here and abroad, becoming a master of car construction.

Mr. Tracy was for some time with the Premier Motor Corporation, Indianapolis, Ind., with which he held the position of director of purchases.

He did invaluable work in Washington in connection with the production of military trucks. His surprising fund of information was a continuous gratification to his friends. He was indefatigable in the pursuit of his duties, and a model of courtesy and affability. His pass-

V. G. Souder, formerly service engineer for the General Motors Export Company of New York City, has made a change to the General Motors Corporation and is stationed in Washington, D. C.

Charles H. Tavener, student, Massachusetts Institute of Technology, has taken a position in the engineering department of the Curtiss Engineering Corporation in Garden City, N. Y.

William Taylor has gone from the Militor Corporation, Jersey City, to Smith, Hinchman & Grills, Detroit, as engineer.

S. P. Thacher has changed his position as experimental engineer for the U. S. Rubber Company and is now technical assistant to the president of the U. S. Tire Company, New York City.

Harold T. Thompson, until recently factory superintendent of the Abbott Corporation, Cleveland, has taken a position as foreman of heat treating in the Grant Munition Factory, Findlay, Ohio.

Frank A. Walter is now assistant chief engineer with J. C. Degan, Inc., Chicago. He was until recently with the Service Machine Corporation of Chicago.

J. W. White, Jr., has been taken on by the General Motors Corporation of Detroit as engineer in the truck axle division. Mr. White was formerly with the Industry Equipment of Oakland, Cal.

Charles B. Wilson, president and manager of the Wilson Foundry and Machine Company, Pontiac, Mich., has been elected vice-president of the Curtiss Aeroplane & Motor Corporation, Buffalo, N. Y.

ing is a distinct shock and very deplorable loss to the Society and the members.

He was last with the Motors Division of the Quartermaster Corps, in charge of trailer procurement.

Mr. C. J. Kleinjohn, who for several years has been an Associate Member of the Society, died of lobular pneumonia in Buffalo, Oct. 15, after an illness of four days. He was born at Louisville, Ky., in 1884 and educated in his home town. After four years of study he received a degree from the International Correspondence Schools, having followed its course in conjunction with practical training with manufacturing companies. He was at one time tool inspector with the Premier Motor Corporation. He took a year's training with the Missouri Pacific Railroad Co. and taught a year in the Kentucky State Reform School. At the time of his death he was with the Curtiss Aeroplane & Motor Corporation.

S. A. E. Service Directory

THE following list contains the names of all the members who have entered the services of the Government up to Nov. 30. The names are listed in two parts, the first showing the members who have actually entered into military services and the second those who are engaged as civilians. While efforts have been made to have this list contain the names of all those who are entitled to mention therein and to have the addresses correct, it is realized that when changes are occurring as rapidly as they do in the Government personnel at the present time errors are likely to creep in. It is therefore requested that in case of any such error the member concerned inform the New York office of the Society immediately so that the proper correction can be made. Members who have actually entered the service in any capacity and are not listed should also write the details to the New York office.

MILITARY

A

ADAMS, PORTER H., ensign, aide to commanding officer, U. S. Naval Air Station, *Chatham, Mass.*
 ADAMS, RALPH, first lieutenant, Engineering Division, Motor Transport Corps, *Washington*.
 ALDRIN, ALBERT W., lieutenant colonel, Engineering Bureau, Ordnance Corps, *Washington*.
 ALDRIN, EDWIN E., first lieutenant, Coast Artillery Corps, Air Service, Mass. Inst. of Tech., *Cambridge, Mass.*
 ALTER, ARTHUR S., chief machinist's mate, Air Service, U. S. N. R. F., *Washington*.
 AMES, AZEL, major, Coast Artillery Corps, A. E. F., *France*.
 AMON, CARL H., first lieutenant, Air Service, 21st Engineers, A. E. F., *France*.
 ANDERSON, E. S., first lieutenant, Air Service, Military Aeronautics, Rockwell Field, *San Diego, Cal.*
 ANDERSON, OSCAR G., private, Co. A, 1st Prov. Ordnance Depot Battalion, A. P. O. No. 713, A. E. F., *France*.
 ARNOLD, BION J., lieutenant colonel, Air Service, *Washington*.

B

BACON, CHARLES V., captain, Engineer Corps, assistant to chief Division of Investigation, Research and Development, 20th & B Sts., N. W., *Washington*.
 BAKER, FRANCIS H., chief machinist's mate, U. S. N. R. F., Naval Gas Engine School, Columbia University, *New York City*.
 BARE, ERWIN L., first lieutenant, Engineering Div., Motor Transport Corps, 358 Union Station, *Washington*.
 BARNABY, R. S., ensign, U. S. N. R. F. C., American Naval Forces in European waters.
 BARNES, NEVIN C., cadet, Flying Squadron No. 3, Kelly Field No. 2, *San Antonio, Tex.*
 BARTON, W. E., first lieutenant, Quartermaster Corps, Mobile Repair Shop 303, A. P. O. 708, A. E. F., *France*.
 BATES, W. O., JR., first lieutenant, Motor Equipment Section, Carriage Division, Ordnance Corps, *Washington*.
 BEDFORD, WALTER G., A. E. F., *France*.
 BENJAMIN, DAVID, Co. A, 326th Machine Gun Battalion, A. E. F., *France*.
 BERGENHOLTZ, N. G., private, Co. E, 11th Supply Train, *Camp Meade, Md.*
 BEVIN, SYDNEY B., captain, Ordnance Corps, Engineering Division, Motor Equipment Section, *Washington*.
 BIBB, JOHN T., JR., second lieutenant, reserve military aviator, 51st Aero Squadron, Mitchell Field, *Hempstead, Long Island, N. Y.*
 BIGELOW, A. C., first lieutenant, commanding Truck Company 445, Motor Transport Corps, *Camp Holabird, Md.*
 BILLINGS, C. M., first lieutenant, Motor Equipment Section, Engineering Div., Ordnance Corps, 448 N. Capitol Ave., *Indianapolis*.
 BISHOP, CHARLES D., chief mechanic, Battery C, 33rd Regiment Field Artillery, *Camp Meade, Md.*
 BLAIR, C. A., sergeant, Air Service, London, S. W. I., England, 472d Aero Squadron.
 BLANK, M. H., captain, Engineering Div., Motor Equipment Sec., Ordnance Corps, Grant Motor Car Co., *Cleveland*.
 BLEAKLEY, P. A., lieutenant, Mobile Ordnance Corps, A. E. F., *France*.
 BLOOD, HOWARD E., major, business executive, Airplane Engineering Div., Bu. of Aircraft Production, *Dayton, Ohio*.
 BOEDECKER, KENNETH J., chief machinist's mate, U. S. Naval Air Station, *Paullac, Gironde, France*.
 BOGGS, GEORGE A., second lieutenant, Motor Transport Corps, Advance Overhaul Park 1, A. E. F., *France*.
 BOOTH, FRED C., U. S. A., *Camp Sherman, Ohio*.
 BOWEN, CARL H., captain, Experimental and Testing Laboratory, Engineering Division, Motor Transport Corps, *Camp Holabird, Md.*

BREWER, ROBERT W. A., captain, inspector mechanical transports, British Army, London, Eng.; Holt Mfg. Co., *Stockton, Cal.*
 BRIDGE, ROBERT B., first lieutenant, engineer officer, Air Service, Aircraft Accept. Park No. 1, Phase 2, A. E. F., *France*.
 BRINTON, BRADFORD, major, Quartermaster Corps, A. E. F., *France*.
 BRISCOE, FRANK, captain, Air Service, *Washington*.
 BRITTON, DANIEL L., captain, Inspection Division, Ordnance Corps, Cleveland District Ordnance Office, *Cleveland, Ohio*.
 BRITTON, W. M., major, Salvage and Engineering Maintenance Division, Motor Transport Corps, *Washington*.
 BRODIE, JAMES S., first lieutenant, Engineer Corps, in charge Engineer Sub-Depot, *Fort Benjamin Harrison, Ind.*
 BROWN, HAROLD HASKELL, captain, Coast Artillery Corps, *Fort Totten, N. Y.*
 BROWNE, ARTHUR B., major, Motor Transport Corps, *Washington*.
 BUBNA, R. C., second lieutenant, designer, Engineering Division, Motor Transport Corps, Room 358, Union Station, *Washington*.
 BURNSIDE, M. C., major, Air Service, Aviation Repair Depot, *Dallas, Tex.*
 BUXTON, LELAND H., second lieutenant, Transportation Div., Quartermaster Corps, Camp Custer, *Battle Creek, Mich.*

C

CALLAN, JOHN LANSING, lieutenant commander, Reserve Flying Corps, U. S. N., Naval Aviation Forces, *Italy*.
 CAMPBELL, ARCHIBALD F., cadet, U. S. School of Military Aeronautics, Barracks 2, *Urbana, Ill.*
 CAROLIN, NORBERT, captain, Air Service, Military Aeronautics, *Washington*.
 CASE, GEORGE S., major, Chemical Warfare Service, *Washington*.
 CERVENKA, JOHN A., captain, commander of casualties, Quartermaster Corps, Camp Meigs, *Washington*.
 CHAPMAN, ROBERT H., ensign, U. S. N. R. F., Aeronautical Inspection, Lewis Spring & Axle Co., *Chelsea, Mich.*
 CHASE, A. M., major, Ordnance Corps, A. E. F., *France*.
 CHURCHWARD, A. GRAY, second lieutenant, Air Service, Third Air Service Mechanics, A. E. F., *France*.
 CLANCY, WILLIAM C., ensign, Aircraft Division, Bu. of Construction & Repair, Navy Dept., *Washington*.
 CLARK, EDWARD L., first lieutenant, 401st Telegraph Battalion, A. E. F., *France*.
 CLARK, ELMER J., captain, Plant Facilities Dept., Bu. of Aircraft Production, *Washington*.
 CLARK, VIRGINIUS E., lieutenant colonel, Air Service, *Dayton, Ohio*.
 CLARKE, A. FIELDER, Ground School, Air Service, U. S. N., *Washington*.
 CLARKE, THOMAS A., lieutenant, Air Service, *Washington*.
 CLAUSEN, NILS J., private, Motor Transport Corps School 1, A. P. O. 772, A. E. F., *France*.
 CLEAVER, B. J., sergeant, Medical Dept., Motor Ambulance Experimental Station, 1210 D St., N. W., *Washington*.
 CLEAVER, CHARLES F., captain, A. S. C., British War Dept., London, Eng., inspector, mechanical transport, Peerless Motor Car Co., *Cleveland, Ohio*.
 COCKRILL, EMMET, first lieutenant, plant supervisor, Ordnance Corps, Ford Motor Co., *Highland Park, Mich.*.
 COE, EDWARD M., first lieutenant, Motor Transport Corps, Mechanical Repair Shops No. 302, A. E. F., *France*.
 COFFMAN, DON M., first lieutenant, Bu. of Aircraft Production, *Grand Rapids, Mich.*.
 COLLINS, KENNETH G., first lieutenant, 4th Gruppo Aeroplano, 1st Squadriglia Caproni, Zona di Guerra, A. E. F., *France*.
 COMSTOCK, HERBERT F., second lieutenant, Air Service, A. E. F., *France*.
 CORBETT, W. S., second lieutenant, Motor Truck Repair Dept., A. E. F., *France*.
 COSTELLO, JOHN V., captain, aeronautical engineer, Bu. of Aircraft Production, McCook Field, *Dayton, Ohio*.
 CROWHURST, H. W., lieutenant, experimental laboratory research assistant, Engineering Div., Motor Transport Corps, Camp Holabird, *Colgate Creek, Md.*

D

DAHLQUIST, CHARLES S., major, supervisor of inspection on standardized military trucks, Quartermaster Corps, Motors Division, *Washington*.
 DAYTON, WILLIAM E., sergeant, ordnance, 306th Regiment, Field Artillery, A. E. F., *France*.
 DEE, SIMON R., corporal, Ordnance Motor Instruction School, Raritan Arsenal, *Metuchen, N. J.*
 DEEDS, EDWARD A., colonel, *Washington*.
 DE JARNY, M. E., captain, French Army, Commissariat General des Affaires de Guerre Franco-American, *Paris, France*.
 DE LA GARDE, LOUIS A. C., lieutenant, British Army, staff of Eastern command, Headquarters, *London, England*.
 DE LA GRANGE, AMAURY, captain, French Army, 95 Rue de l'Universite, *Paris, France*.
 DE LORENZI, ERNEST A., officer, Mechanical Transport, *London, England*.
 DENISON, ARTHUR H., second lieutenant, Air Service, Hazelhurst Field, *Mineola, Long Island, N. Y.*
 DE TURK, L. M., musician, 312th Field Artillery Band, Headquarters 79th Div., A. E. F., *France*.
 DE WITT, GORGEO W., lieutenant, U. S. N., U. S. S. Utowana, Postmaster, *New York City*.
 DIAMOND, JAMES E., captain 310th Mobile Ordnance Repair Shop, 85th Division, 5th Army Corps, A. E. F., *France*.
 DICK, ROBERT L., corporal, motor truck expert, Ordnance Corps, 1st Heavy Mobile Ordnance Repair Shop, A. E. F., *France*.

DICKEY, HERBERT L., captain, Motor Equipment Sec., Engineering Bureau, Ordnance Corps, A. E. F., France.
 DONALDSON, FRANK A., captain, engineer, Motor Equipment Sec., Carriage Div., Ordnance Corps, Washington.
 DOST, CHARLES O., first lieutenant, Engineering Div., Air Service, Ellington Field, Houston, Texas.
 DU BOSE, GEORGE W. P., major, American Ordnance Base Depot, A. E. F., France.
 DUNCAN, A. C., first lieutenant, Branch Intelligence Officer, 4th Corps, Air Service, A. P. O. 775, A. E. F., France.
 DUNSTON, LLOYD B., first lieutenant, Ordnance Corps, Engineering Motor Equipment Section, Washington.

E

EARL, LAWRENCE H., captain, ordnance inspector, Ordnance Corps, Holt Mfg. Co., Peoria, Ill.
 ELLS, PAUL W., lieutenant, 330th Field Artillery, A. E. F., France.
 EGGEN, O. E., private, 337th Field Artillery, Ordnance Corps, Camp Dodge, Iowa.
 EHLERS, PAUL, Battery E, 304th Field Artillery, A. E. F., France.
 EISELE, WILLIAM S., private, first-class aeronautical draftsman, 239th Aero Squadron, Payne Field, West Point, Miss.
 ELLWOOD, A. L., major, 3rd Motor Mechanics Air Service, A. E. F., France.
 ENGESEER, BENJ. M., second lieutenant, Air Service, Engineering Dept., Post Field, Fort Sill, Okla.
 ENGLISH, G. H., Jr., first lieutenant, Ordnance Corps, Washington.
 EVANS, GORDON M., captain, Engineering Div., Motor Equipment Section, Ordnance Corps, Washington.

F

FARRELL, MATTHEW, captain, automotive engineer, Motor Transport Corps, Washington.
 FINK, GEORGE R., captain, Ordnance Corps, Detroit, Mich.
 FINKENSTAEDT, EDWARD R., captain, Truck Sec., Motors and Vehicles Div., Quartermaster Corps, Washington.
 FISHLEIGH, W. T., lieutenant colonel, Engineering Div., Motor Transport Corps, Washington.
 FITZGERALD, GERALD, first lieutenant, Motor Truck Co. No. 348, Camp McArthur, Texas.
 FLANIGAN, E. B., first lieutenant, Motor Transport Corps, M. S. T. U. 405, A. E. F., France.
 FLIEDNER, CARLYLE S., ensign, Air Service, U. S. N., Paulliac, Gironde, France.
 FORRER, J. D., captain, Engineer Corps, Washington.
 FOSS, CLARENCE M., captain, Motor Section, Ordnance Corps, Rock Island Arsenal, Rock Island, Ill.
 FOSTER, WILLIAM J., second lieutenant, aeronautical mechanical engineer, Bu. of Aircraft Production, Washington.
 FOX, RUDOLPH H., first lieutenant, Ordnance Corps, Springfield Armory, Springfield, Mass.
 FRANKLIN, G. KING, captain, 5th Heavy Motor Ordnance Repair Shop, A. P. O. 733, A. E. F., France.
 FRANKS, J. B. JR., lieutenant, Motor Transport Corps, P. O. 717, A. E. F., France.
 FREDRICKSEN, ARTHUR, chief machinist's mate, Naval Aviation Officers' Material School, Pelham Bay Naval Training Station, N. Y.
 FRESH, A. W., captain, Engineering Division, Motor Transport Corps, Washington.
 FREVERT, CARL B., first lieutenant, Ordnance Corps, A. E. F., France.
 FRIEDEN, A. E., first lieutenant, Motor Transport Corps, Washington.
 FRUDDEN, C. E., captain, Motors Div., Quartermaster Corps, New York City.
 FULTON, RICHARD WALLACE, lieutenant, Air Service, 5th Cadet Squadron, A. P. O. 717, A. E. F., France.
 FUNKE, L. H., U. S. Naval Reserve Force, assistant inspector machinery, Bu. of Steam Engineering, Allis-Chalmers Mfg. Company, Milwaukee, Wis.
 FURLOW, JAMES W., colonel, General Staff, Deputy Chief of Motor Transport Corps, Washington.

G

GAEBELEIN, ARNO W., captain, Procurement Division, Artillery Section, Ordnance Corps, Washington.
 GARDNER, LESTER D., major, Supply Section, Air Service, Division of Military Aeronautics, Washington.
 GEISTERT, ALBERT G., chief machinist's mate, U. S. N. R. F., Naval Aviation Engineering Div., Washington.
 GEORGE, EDWIN S., colonel, Motors Division, Quartermaster Corps, Washington.
 GETSCHMAN, G. F., second lieutenant, Ordnance Corps, Maxwell Motor Co., Chalmers Plant, Detroit, Mich.
 GEY, WILLIAM, 377th Truck Train, Camp Merritt, Tenafly, N. J.
 GFRERER, A. H., first lieutenant, production officer, Engineering Division, Ordnance Corps, Miller Corp., Jersey City, N. J.
 GILL, RAYMOND, machinist's mate, U. S. N., Puget Sound Navy Yard, Bremerton, Wash.
 GITLITZ, ALBERT, private, U. S. Army Training Detachment, Old South Division High School, Chicago.
 GLOVER, FRED, colonel, Motors Division, Quartermaster Corps, Washington.
 GOLDSBOROUGH, PAUL, captain, Air Service, Carlstrom Field, Arcadia, Fla.
 GOOD, JOHN, lieutenant, U. S. N. R. F., New London, Conn.
 GORELL, EDGAR S., lieutenant colonel, Air Service, A. E. F., France.
 GOULD, ALLEN A., captain, Headquarters 37th Div., Motor Transport Corps, A. E. F., France.

GRAHAM, LOUIS, captain, Engineer Corps, Camp Leach, Washington.
 GRAY, SAMUEL W., first lieutenant, Air Service, 4th Co., 2d Motor Mechanics Regiment, A. E. F., France.
 GREEN, GEORGE A., major, Tank Corps, British E. F., France.
 GUERNSEY, CHARLES, captain, designer, Engineering Div., Motor Transport Corps, Washington.
 GUTHRIE, JAMES, major, Carriage Div., Engineering Bu., Ordnance Corps, Washington.

H

HACH, EDWARD C., private, Co. C, S. O. T. C., E. Lansing, Mich.
 HAESKE, F. C., lieutenant, Camp Sherman, Chillicothe, Ohio.
 HALL, C. M., major, Air Service, Dayton, Ohio.
 HALL, ELBERT J., lieutenant colonel, Bu. of Aircraft Production, Air Service Bldg., Dayton, Ohio.
 HALL, RICHARD H., Jr., captain, 1st Infantry Replacement & Training Battalion, Camp Lee, Va.
 HALLETT, GEORGE E. A., major, Military Aeronautics, Technical Section, Testing Dept., Wilbur Wright Field, Fairfield, Ohio.
 HARMS, HENRY W., lieutenant colonel, Air Service, Base Section No. 3, London, England.
 HART, FRANK S., second lieutenant, Motor Transport Corps, Washington.
 HASKELL, A. G., sergeant, Motor Transport Corps, Mechanical Repair Shop Unit 302, Co. 3, A. P. O. 772, A. E. F., France.
 HASKINS, HOWARD B., chief machinist's mate, Naval Steam Engineering School, Stevens Institute, Hoboken, N. J.
 HAWKE, CLARENCE E., engineer officer, Air Service, Washington.
 HAYES, RALPH S., first lieutenant, Quartermaster Corps, Washington.
 HEASLET, JAMES G., major, district manager of production, Bu. of Aircraft Production, 1550 Woodward Ave., Detroit, Mich.
 HECKEL, C. E., second lieutenant, Engineering Div., Motor Transport Corps, Washington.
 HECOX, F. C., major, Headquarters, Motor Transport Corps, A. P. O. 717, A. E. F., France.
 HEGEMAN, HARRY A., lieutenant colonel, Motor Transport Repair Shops, A. P. O. 708, A. E. F., France.
 HENDERSON, S. W., first lieutenant, Engineering Division, Ordnance Corps, Washington.
 HERRINGTON, A. W. S., first lieutenant, Engineering Div., Motor Transport Corps, A. E. F., France.
 HICKS, CHARLIE H., captain, Air Service, A. E. F., France.
 HIGGINBOTHAM, P. R., captain, chief ordnance officer, A. E. F., France.
 HILL, DWIGHT BRADFORD, first lieutenant, Engineers Corps, Washington.
 HILL, NESTOR FRANCIS, first lieutenant, Mechanical Repair Shop Unit 307, Motor Transport Corps, A. E. F., France.
 HIRTZEL, CLEMENT H. A., major, Royal Air Force & Aircraft Production, London, England.
 HOBES, J. W., first lieutenant, Ordnance Corps, 4th Heavy Artillery, Mobile Ordnance Repair Shop, A. E. F., France.
 HOFFMAN, ROBSON C., captain, Motor Equipment Section, Engineering Division, Ordnance Corps, 448 No. Capitol Ave., Indianapolis, Ind.
 HONIGMAN, J. K., second lieutenant, Air Service, instructor, Engineering Dept., U. S. School of Military Aeronautics, Princeton, N. J.
 HORINE, M. C., second lieutenant, Air Service, Souther Field, Americus, Ga.
 HORNER, LEONARD S., lieutenant colonel, Bu. of Aircraft Production, Washington.
 HOWLAND, W. L., Jr., lieutenant, Bu. of Ordnance, Navy Department, U. S. N. R. F., Washington.
 HOYT, FRED A., sergeant, 30th Co., 8th Battalion, Camp Upton, Long Island, N. Y.
 HUBBELL, LINDEY D., lieutenant colonel, works manager, Ordnance Corps, Springfield Armory, Springfield, Mass.
 HULL, M. LAIR, private, Production Division, Ordnance Corps, Connersville Furniture Co., Connersville, Ind.
 HUNT, CHARLES E., machinist's mate, Naval Operating Base, Co. 1142, Hampton Roads, Va.
 HYDE, C. M., private, inspector, Motor Transport Equipment, Quartermaster Corps, Washington.

I

IAGO, NORMAN JOHN, private, Co. E, 8th Division, M. S. Train, Camp Holabird, Md.

J

JACO, E. L., major, Engineer Corps, Motors Div., Quartermaster Corps, New York City.
 JEFFREY, MAX L., captain, Military Truck Production Section, Quartermaster Corps, Washington.
 JENKS, WESTON M., ensign, U. S. N. R. F., instructor in Aerial Observation, Naval Aviation, Mass. Inst. of Tech., Cambridge, Mass.
 JENNINGS, J. J., first lieutenant, Engineer Corps, A. P. O. 717, A. E. F., France.
 JOHNSON, COURTNEY, captain, 103rd Field Artillery, A. E. F., France.
 JONES, R. E., lieutenant, U. S. N. R. F., U. S. S. New York, Postmaster, New York City.
 JUNK, FRED H., second lieutenant, Air Service, Aviation School, Carlstrom Field, Arcadia, Florida.

K

KALB, LEWIS P., major, Motor Transport Corps, Washington.
 KEGERREIS, CLAUDE S., 16th Co., 4th Battalion, 159th Depot Brigade, Camp Taylor, Ky.

S. A. E. SERVICE DIRECTORY

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KENDRICK, JOHN F., sergeant, Signal Corps, Research Inspection Division, A. E. F., France.
 KENNEDY, H. H., captain, inspector, Ordnance Corps, Best Traction Co., Platt Iron Works, Dayton, Ohio.
 KENT, RICHARD, Co. B, 302d Battery, Tank Corps, A. E. F., France.
 KERR, C. P., captain, Air Service, Technical Section, A. E. F., France.
 KINKEAD, R. S., second lieutenant, Field Artillery, A. E. F., France.
 KIRKPATRICK, ANDREW, lieutenant, Commanding Service Park Unit 452, Motor Transport Corps, Camp Jesup, Atlanta, Ga.
 KISHLINE, FLOYD F., first lieutenant, Engineering Div., Motor Transport Corps, Camp Holabird, Md.
 KLEMIN, ALEXANDER, second lieutenant, Aeronautical Research Dept., Airplane Engineering Div., Bu. of Aircraft Production, McCook Field, Dayton, Ohio.
 KLINE, HARMON J., first lieutenant, Explosives Section, Engineering Division, Ordnance Corps, Washington.
 KLOCKAU, W. F., private, Co. H, 138th Infantry, 35th Division, A. E. F., France.
 KNAUER, C. H., 7th Co., 161st Depot Brigade, Camp Grant, Ill.
 KNEPPER, F. B., second lieutenant, Co. A, 507th Engineers, Engineer Corps, A. E. F., France.
 KOHR, ROBERT F., second lieutenant, Engineers Corps, Worgret Camp, Wareham, Dorset, England.
 KOTTAUER, EDWIN H., first lieutenant, inspector, Ordnance Corps, Cotta Transmission Co., Rockford, Ill.
 KROEGER, F. C., captain, Engineering Division, Motor Transport Corps, Washington.
 KUENZEL, S. H. HUNTER, private, Supply Co., 70th Artillery, Coast Artillery Corps, A. E. F., France.

L

LANDON, CHARLES H., second lieutenant, Air Service, Barron Field, Everman, Tex.
 LANE, ABBOT A., captain, Bu. of Aircraft Production, 1550 Woodward Ave., Detroit, Mich.
 LANZA, MANFRED, major, 303rd Motor Supply Train, A. E. F., France.
 LARSEN, LESTER REGINALD, first lieutenant, 107th Engineer Train, A. E. F., France.
 LAUTH, FRED P., machinist's mate, aviation, U. S. N., Washington.
 LAVERY, GEORGE L., JR., first lieutenant, Mobile Ordnance Repair Shop, 6th Division, Ammunition Train, A. E. F., France.
 LE FEVRE, W. G., lieutenant, 302d Ammunition Train, Ordnance Corps, A. E. F., France.
 LEOPOLD, JOSEPH, second lieutenant, Air Service, Hazelhurst Field, Mineola, Long Island, N. Y.
 LEVY, ALFRED K., private, layout on tanks, Motor Equipment Section, Ordnance Corps, Washington.
 LEWIS, CHARLES B., captain, Ordnance Corps, Augusta Arsenal, Augusta, Ga.
 LEWIS, HARRY R., JR., captain, Ordnance Corps, Springfield Armory, Springfield, Mass.
 LIBBEY, E. B., captain, 102d Ammunition Train, A. E. F., France.
 LINCOLN, C. W., private, Co. E, 3rd Regiment, Air Service Mechanics' School, St. Paul, Minn.
 LIPPS, WALTER M., private, 27th Co., 3rd Regiment, 159th Depot Brigade, Camp Taylor, Ky.
 LIPSNER, B. B., captain, Air Service, Washington.
 LOEB, S. ARTHUR, lieutenant, Bu. of Aircraft Production, General Motors Corp., Buick Division, Flint, Mich.
 LONN, JULIUS M., captain, inspector, Ordnance Corps, Frankford Arsenal, Philadelphia, Pa.

M

MCCORMICK, BRADLEY T., captain, Ordnance Corps, New York City.
 MCINTYRE, H. C., captain, Ordnance Corps, A. E. F., France.
 MCMASTER, MARCUS D., machinist, U. S. Naval Air Station, Pauillac, France.
 MCINTURST, ALDEN L., major, War Plans Div., General Staff, War College, Washington.
 MACCOUL, NEIL JR., U. S. N. R., Naval Air Base, Pauillac, France.
 MACDONALD, K. B., lieutenant commander, U. S. N. R. F., Naval Aircraft Factory, League Island Navy Yard, Philadelphia.
 MACKIE, MITCHELL, major, Motor Transport Corps, A. E. F., France.
 MACPHERSON, EARL S., captain, Technical Section, engineer officer, Air Service, A. E. F., France.
 MANN, ARTHUR S., lieutenant, Sanitary Corps, Kankakee, Ill.
 MARMON, HOWARD, major, Bu. of Aircraft Production, Experimental Engineering Subdivision, McCook Field, Dayton, Ohio.
 MARSHALL, W. C., captain, Ordnance Corps, Washington.
 MARTIN, KINGSLEY G., major, Motor Transport Corps, A. P. O. 701, A. E. F., France.
 MARX, FRANK W., Co. K, Ft. Sheridan Training Camp, Ft. Sheridan, Ill.
 MASON, GEORGE R., lieutenant, Motor Transport Corps, A. E. F., France.
 MATTHEWS, MEREDITH, second lieutenant, Ordnance Corps, Ordnance Motor Instruction School, Raritan Arsenal, Metuchen, N. J.
 MAY, HENRY, JR., first lieutenant, inspector, Quartermaster Corps, Hinkley Motors Corp., Detroit, Mich.
 MAYER, JAMES L., lieutenant, 109th Engineers, Camp Cody, New Mexico.
 MAYNARD, W. A., ensign, U. S. N. R. F., Kingston, Mich.
 MEDER, CHARLES, machinist's mate, Naval Air Station, Pensacola, Fla.
 MEREDITH, ROY B., ensign, U. S. N. R. F., engineer, Naval Academy, Annapolis, Md.
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JOHNSON, FREDERICK H., inspector of airplanes, Bu. of Construction and Repair, U. S. N., Gallaudet Aircraft Corp., E. Greenwich, R. I.
 JOHNSTON, W. S., Engineering Department, Naval Aircraft Factory, Navy Yard, Philadelphia.

K

KEAGY, GEORGE H., production engineer, New York Shipbuilding Corp., Camden N. J.
 KINGSBURY, J. A., metallurgist, Ordnance Corps, Trego Motors Corp., New Haven, Conn.
 KLEIN, ADOLPH, designer, Engineering Div., Motor Transport Corps, Washington.
 KOECKERT, ALBERT E., draftsman, Nitrate Division, Ordnance Corps, Washington.
 KOLBE, A. E., Motor Transport Corps, Fort Sheridan, Ill.
 KUEMPEL, REUBEN, U. S. N. Naval Air Station, Bu. of Steam Engineering, Pensacola, Fla.
 KUIVINEN, JOHN VICTOR, inspector and testor, automobile ambulances, Sanitary Corps, Washington.

L

LEADDON, I. M., aeronautical engineer, Bu. of Aircraft Production, Packard Motor Car Co., Detroit.
 LEAVELL, R. A., mechanical engineer, Motor Transport Branch, Committee on Education and Special Training, Washington.
 LE CAIN, J. H., instructor, 1st U. S. Naval Aviation Detachment, Mass. Inst. of Tech., Cambridge, Mass.
 LONGLETZ, WESLEY, inspector, airplane engines, Bu. of Aircraft Production, Nordyke & Marmon Co., Indianapolis, Ind.
 LOOMIS, ALLEN, Airplane Engineering Department, Bu. of Aircraft Production, McCook Field, Dayton, Ohio.
 LUDOLPH, F. E., aeroplane mechanic, 69th Aero Squadron, Ellington Field, Houston, Texas.
 LOUDON, WARREN P., expert cost accountant, Signal Corps, New York City.

M

MCCAIN, GEORGE L., final design engineer, Airplane Engineering Dept., Bu. of Aircraft Production, McCook Field, Dayton, Ohio.
 McDONALD, E. G., aeronautical engineer, Airplane Engineering Dept., Bu. of Aircraft Production, McCook Field, Dayton, Ohio.
 MCGILL, GEORGE E., draftsman, Bu. of Aircraft Production, Lincoln Motor Co., Detroit, Mich.
 MCINTOSH, J. M., Military Truck Transportation Sec., Quartermaster Corps, Washington.
 MCINTYRE, JOHN W., Students Army Training Corps, Barracks 14, Indiana University, Bloomington, Ind.
 MACPHERSON, JAMES W., inspector of airplanes and engines, Signal Service at Large, Washington.
 MADISON, R. D., chief draftsman, Motor Equipment Section, Ordnance Engineering Bureau, Indianapolis, Ind.

MENNEN, F. E., Engineering Div., Motor Transport Corps, Washington.
 MEREDITH, G. W., senior inspector of airplanes and engines, Bu. of Aircraft Production, Fisher Body Corp., Detroit, Mich.
 MILLAR, THOMAS H., Jr., Engineering Div., Motor Transport Corps, Washington.
 MOORHOUSE, A., executive research engineer, Airplane Engineering Dept., Bu. of Aircraft Production, Dayton, Ohio.
 MORGAN, E. TASSO, inspector of airplanes and engines, Bu. of Aircraft Production, Packard Motor Car Co., Detroit, Mich.
 MORGAN, G. W., supervisor of work in process, Motors Division, Office Quartermaster General, Washington.
 MOSKOVICS, GEO. L., inspector, airplanes and engines, Bu. of Aircraft Production, Detroit, Mich.

N

NELSON, A. L., consulting engineer, armament, Bu. of Aircraft Production, McCook Field, Dayton, Ohio.
 NESTLEN, HOWARD, senior inspector, Bu. of Aircraft Production, Standard Turnbuckle Co., Roseville Park, N. J.
 NEUMANN, JOHN W., assistant planning superintendent, Navy Yard, Philadelphia.
 NORTON, F. H., aeronautical engineer, Research Department, Bu. of Aircraft Production, Mass. Inst. of Tech., Cambridge, Mass.

O

OBER, SHATSWELL, aeronautical engineer, Airplane Engineering Dept., Bu. of Aircraft Production, Mass. Inst. of Tech., Cambridge, Mass.
 O'MALLEY, JOHN M., aeronautical engineer, Air Service Flying School, Rockwell Field, San Diego, Cal.

P

PARISH, W. F., Division of Military Aeronautics, Supply Section, Chief of Oil and Lubrication Branch, Washington.
 PARRIS, EDWARD L., Jr., senior inspector, aeronautical and marine ignition, Bu. of Aircraft Production, Ericsson Mfg. Co., Buffalo, N. Y.
 PETERSON, F. L., Ordnance Corps, Headquarters, Tractor Artillery School, A. E. F., France.
 PLIMPTON, R. E., Specification Sec., Engineering Div., Motor Transport Corps, Washington.
 POMEROY, G. M., aeronautical mechanical engineer, Naval Aircraft Factory, Navy Yard, Philadelphia.
 PRINCE, LOUIS A., chief special mechanic, U. S. N. R. F. C., Barracks 315, Philadelphia Navy Yard, Philadelphia, Pa.
 PUFF, MICHAEL J., designer, Engineering Div., Bu. of Aircraft Production, McCook Field, Dayton, Ohio.

Q

QUINN, W. J., laboratory assistant, Engineering Div., Motor Transport Corps, Camp Holabird, Baltimore, Md.

R

RANDALL, J. M., assistant inspector of ordnance, Ordnance Corps, Nash Motors Co., Kenosha, Wis.
 RANDLES, GEORGE E., Maintenance Div., Motor Transport Corps, Washington.
 REID, JAMES, superintendent, Forge Dept., Boston Navy Yard, Boston.
 RICE, HARVEY M., inspector of airplane engines, Bu. of Aircraft Production, Willys-Overland Co., Toledo, Ohio.
 RIDER, W. KEITH, engineer, Engineering Div., Bu. of Aircraft Production, Dayton, Ohio.
 ROBERTS, D. S., inspector of airplanes, Bu. of Aircraft Production, Sturtevant Aeroplane Co., Boston.
 ROBERTS, E. W., National Advisory Committee for Aeronautics, Bureau of Standards, Washington.
 ROBERTS, SAMUEL B., inspector of airplanes, Bu. of Aircraft Production, Walden-Worcester Co., Worcester, Mass.
 ROONEY, JOHN J., aeronautical engineer, U. S. N., Aviation Sec., Engineering Dept., Bu. of Construction and Repair, Washington.
 RUSSEL, A. W., office of Assistant Secretary of War, Washington.
 RUSSELL, HARTWELL B., draftsman, Engineering Div., Bu. of Aircraft Production, McCook Field, Dayton, Ohio.
 RUSSELL, L. L., squad foreman, Engineering Office, Motor Transport Corps, Washington.
 RYMARCZICK, GUSTAV M., supervising senior inspector, Magneto Section, Bu. of Aircraft Production, 480 Lexington Ave., New York City.

S

SCHAUM, FLETCHER, Officers' Training School, Motor Transport Corps, Philadelphia, Pa.
 SCHELL, JOHN A., aeronautical mechanical engineer, Airplane Engineering Dept., Bu. of Aircraft Production, McCook Field, Dayton, Ohio.
 SCHUEHLE, WALTER A., aeronautical mechanical engineer, Engineering Div., Bu. of Aircraft Production, Dayton, Ohio.
 SCHULTHEIS, EVERETT M., gauge standardization, Bu. of Aircraft Production, Nordyke & Marmon Co., Indianapolis, Ind.
 SCHWAB, CHARLES M., aeronautical mechanical engineer, Bu. of Aircraft Production, New York City.

APPLICANTS FOR MEMBERSHIP

399

SCHWINN, FRANK W., Military Standards Board, Transport Div., Quartermaster Corps, *Washington*.
 SCOTT, GEORGE A., Mobile Repair Shop 302, Co. 2, A. E. F., *France*.
 SEABURY, W. WARNER, tester, aviation instruments, Signal Corps, Bu. of Standards, *Washington*.
 SELLERS, MATTHEW B., Naval Consulting Board, *New York City*.
 SERRELL, ERNEST, radio inspector, Signal Corps, Eastern Division, *New York City*.
 SHAW, B. RUSSELL, assistant director of flying, Airplane Engineering Div., Bu. of Aircraft Production, McCook Field, *Dayton, Ohio*.
 SHILLINGER, G. P., instructor in ignition, starting and lighting, Ground Officers' Engineering School, Kelly Field No. 1, *San Antonio, Tex.*
 SHIRE, HARRY I., aeronautical mechanical engineer, Plane Department, Bu. of Aircraft Production, *Detroit, Mich.*
 SIMMONS, CHARLES F., factory manager, Engineering Div., Bu. of Aircraft Production, McCook Field, *Dayton, Ohio*.
 SMITH, CARLISLE F., Co. F, Candidates' School, *Fort Monroe, Va.*
 SMITH, G. W., chief of inspection, Detroit district, Motors Div., Quartermaster Corps, *Detroit, Mich.*
 SOULIS, HAROLD A., mechanical engineer, Loading Section, Production Div., Ordnance Corps, *Washington*.
 SPENCER, LESLIE V., editor, technical publications, Airplane Engineering Dept., McCook Field, *Dayton, Ohio*.
 SPRAGLE, R. L., Bu. of Aircraft Production, *Detroit, Mich.*
 STEARNS, L. C., technical assistant, National Advisory Committee for Aeronautics, *Washington*.
 STEVENS, C. C., chief draftsman, Ordnance Corps, Engineering Station, *Jersey City, N. J.*
 STUART, H. R., aeronautical mechanical engineer, Bu. of Aircraft Production, Air Service Building, *Dayton, Ohio*.
 SUTTILL, ALBERT G., inspector of machinery, Merchant Shipbuilding Corp., Boston district, *Hyde Park, Mass.*

T

THIBAULT, F. J., aeronautical mechanical engineer, Bu. of Aircraft Production, McCook Field, *Dayton, Ohio*.
 THOMAS, T. R., mechanical engineer, Bu. of Aircraft Production, McCook Field, *Dayton, Ohio*.
 THOMPSON, JOHN A., Engineering Bureau, Ordnance Corps, *Washington*.
 TILT, ALBERT, naval constructor, Bureau of Construction and Repair, U. S. Navy, *Washington*.
 TODD, PERCY F., Engineering Div., Bu. of Aircraft Production, *Detroit, Mich.*
 TONE, FRED L., aeronautical mechanical engineer, Research Dept., Bu. of Aircraft Production, *Dayton, Ohio*.
 TURNBULL, D. P., Bureau of Aircraft Production, *Washington*.

V

VANDE WATER, S. R., Engineering Div., Motor Transport Corps, *Washington*.
 VAN DYKE, J. R., assistant secy., Y. M. C. A., Army Base Hospital 11, *Cape May, N. J.*

W

WADE, GUSTAV, engineer, Bu. of Aircraft Production, Air Service Bldg., *Dayton, Ohio*.
 WALDEN, C. O., laboratory assistant, Military Research Gas Engines, National Bureau of Standards, *Washington*.
 WALDRON, RUSSELL E., inspector, airplanes and engines, Bu. of Aircraft Production, *Detroit, Mich.*
 WALTER, JOHN M., mechanical draftsman, Bureau of Ordnance, Navy Department, *Washington*.
 WARNER, ARCHIBALD A., aeronautical mechanical engineer, Bu. of Aircraft Production, *Detroit, Mich.*
 WARNER, EDWARD P., aeronautical engineer, Signal Service at Large, Mass. Inst. of Tech., *Cambridge, Mass.*
 WATERHOUSE, H. D., production engineer, Ordnance Corps, *Bridgeport, Conn.*
 WATSON, J. W., assistant chief, Hispano-Suiza Section, Bu. of Aircraft Production, *New York City*.
 WEAVER, E. W., aeronautical engineer, Engineering Department, Naval Aircraft Factory, Navy Yard, *Philadelphia*.
 WIDRIG, R. E., Air Service, Camp Dick, *Dallas, Texas*.
 WILLIAMS, S. T., aeronautical mechanical engineer, Engineering Dept., Naval Aircraft Factory, Navy Yard, *Philadelphia*.
 WINTER, E. A., tool designer, Rock Island Arsenal, *Rock Island, Ill.*
 WOLFE, W. S., maintenance of tires and rims, Motor Transport Corps, *Washington*.
 WOODWORTH, P. B., district educational director, War Department, Tribune Building, *Chicago*.
 WORTHEN, C. B., inspector, Bu. of Aircraft Production, Eisemann Magneto Co., *Brooklyn, N. Y.*
 WRIGHT, E. H., factory manager's office, experimental department, Bu. of Aircraft Production, McCook Field, *Dayton, Ohio*.

Y

YACKEY, CARL H., assistant inspector, Detroit district, Motor Transport Corps, *Detroit, Mich.*
 YOUNGER, JOHN, chief, Engineering Division, Motor Transport Corps, *Washington*.

Z

ZEITLER, RAYMOND S., Engineering Sec., Motor Transport Div., Quartermaster Corps, *Washington*.
 ZWINGLE, CARL T., Student Army Training Corps, Stevens Institute of Tech., *Hoboken, N. J.*

Applicants for Membership

The applications for membership received between Oct. 15 and Nov. 15, 1918, are given below. The members of the Society are urged to send any pertinent information with regard to these names which the Council should have for consideration prior to their election. It is requested that such communications from members should be sent promptly.

ANDERSON, BIRGER N., mechanical draftsman, Four Wheel Drive Auto Co., *Clintonville, Wis.*
 BEESE, A. J., president, general manager, Saginaw Sheet Metal Works, *Saginaw, Mich.*
 BILL, HARRY L., factory manager, The Winton Co., *Cleveland, Ohio*.
 BOBBENE, FRED J., executive, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*
 BOLD, GEORGE, machinist, Standard Oil Co. of New Jersey, *Bayonne, N. J.*
 BOND, CLARENCE ROBERT, asst. chief engineer, Arvac Manufacturing Co., *Anderson, Ind.*
 BOWERS, LIEUT. CHARLES R., Carlstrom Field, *Arcadia, Fla.*
 BRADLEY, S. L., sales engineer, Ross, Gear & Tool Co., *Lafayette, Ind.*
 BREVAIRE, A. A., general inspection foreman, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*
 BUCKENDALE, CAPT. L. RAY, Engineering Division, Ordnance Corps, Locomobile Company, *Bridgeport, Conn.*
 BURKE, HAROLD J., Air Service, Bureau of Aircraft Production, *New York City*.
 CALLAHAN, JOHN A., factory manager, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*
 CAMPBELL, J. HERBERT, assistant inspection engineer, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*
 CANFIELD, HERBERT A., foreman materials testing laboratory, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*
 CARNAHAN, ORSON A., inspection engineer, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*
 CARSTENS, GEORGE E., chief draftsman, Walker Vehicle Co., *Chicago*.
 CHADWICK, A. E., assistant outside production, Wright-Martin Aircraft Corp., *New Brunswick, N. J.*
 CHURCH, FREDERICK C., charge of inspection manual, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*
 CLOOS, FRED A., inspection buyer, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*
 CONNER, JEFFERSON T., draftsman, Continental Motors Corp., *Detroit, Mich.*
 CORTELYOU, J. S., vice-president, Automobile Trade Directory, *New York City*.
 CREAGER, EMORY F., draftsman, Airplane Engineering Dept., McCook Field, *Dayton, Ohio*.
 DRAKE, HARCOURT C., assistant chief engineer, The Cortland Electric Co. Inc., *Brooklyn, N. Y.*
 EDWARDS, CLYDE L., chief inspector, Dort Motors Car Co., *Flint, Mich.*
 EHRMAN, OSCAR W., mechanical engineer, The Reliable Engine Co., *Portsmouth, Ohio*.
 ELLINGER, A. ELMER, process engineer, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*
 EVERSON, J. A., tractor sales manager, International Harvester Co. of America, *Chicago, Ill.*
 FARMER, EARL H., chief engineer, H. E. Wilcox Motor Co., *Minneapolis, Minn.*
 FARRELL, JAMES P., vice-president, general manager and chief engineer, Farrell, Stoneham & Thompson, *Dayton, Ohio*.
 FISHER, CHARLES S., chief engineer, Detroit Accessories Corp., *Detroit, Mich.*
 FLEMING, D. C., assistant inspector of ordnance materials and motor vehicles, Holt Mfg. Company, *Stockton, Cal.*
 FLOOD, WALTER G., ensign, U. S. N., Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*
 GAU, EMIL, chief instructor, Engine Adjusting Dept., University of Cincinnati, *Cincinnati, Ohio*.

GENTNER, ALBERT J., airplane engineering, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*

GENTZLER, W. J., foreman of tests, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*

GILBERT, FREDERICK C., vice-president, The Timken Detroit Axle Co., *Detroit, Mich.*

GLOVER, J. W., general inspection, foreman of aircraft wood parts, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*

GORTZIG, HAROLD C., inspection foreman, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*

GREUTER, R. E., mechanical engineer, Bureau of Aircraft Production, *New York City.*

GROTS, FRED, metallurgist, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*

GUYER, EUGENE L., chief tool designer, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*

HANGASKY, WILLIAM, superintendent of inspection, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*

HANSOM, CLARENCE DEAN, instructor in aeronautics, Mass. Inst. of Tech., *Cambridge, Mass.*

HANSEN, JULIUS F., superintendent, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*

HECKER, RALPH EDWIN, sales engineer, The Norma Company of America, *New York.*

HIGGINS, WILL LINDFIELD, assistant production engineer, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*

HILTON, W. P., system and routine, Curtiss Aeroplane Motor Corp., *Buffalo, N. Y.*

JACKSON, PHILIP B., designer, Pierce Arrow Motor Car Co., *Buffalo, N. Y.*

JOOST, HENRY, inspection foreman, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*

KELLEY, ERNEST E., superintendent, Industrial Equipment Co., *Oakland, Cal.*

KIMBALL, WALTER F., president, New York & New Jersey Lubricant Co., *New York City.*

KOYA, HISASHI, mechanical engineer, Imperial Japanese Navy, *New York City.*

KRAMMER, HENRY E., engineer, draftsman, 1530 Brook Ave., *Bronx, N. Y.*

LANE, VERNE R., production draftsman, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*

LITTLE, GUY A., inspection department, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*

MARTELL, LEONARD R., president, treasurer, Detroit Accessories Corp., *Detroit, Mich.*

MARTIN, LYLE B., leading draftsman, Engineering Division, Ordnance Corps, *Bridgeport, Conn.*

MARX, HARRY J., aeronautical engineer, Standard Aircraft Corp., *Elizabeth, N. J.*

MASSEY, MARK F., assistant chief draftsman, Ordnance Corps, *Washington.*

MAYTHAM, EDWARD H., assistant to inspection engineer, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*

MUHLE, LIEUT. H. M., Ordnance Motor Instruction School, Raritan Arsenal, *Metuchen, N. J.*

NEILSON, M. A., engineer, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*

OLSON, ALLEN C., mechanical draftsman, Smith, Hinchman & Grylls, *Detroit, Mich.*

OXBERRY, SYDNEY, editorial and art, Class Journal Co., *New York City.*

PARKER, GEORGE C., chief engineer, The Cincinnati Ball Crank Co., *Oakley, Cincinnati, Ohio.*

PENNDLETON, E. R., chief engineer, Hession Tiller & Tractor Corp., *Buffalo, N. Y.*

PETERSON, C. H., superintendent, Olds Motor Co., *Lansing, Mich.*

PETRELLI, SR., JOSEPH V., proprietor, The Navy Gear Mfg. Co., *New Haven, Conn.*

PFIAFF, HARRY C., vice-president, sales manager, Dependable Truck & Tractor Co., *Galesburg, Ill.*

PLIMPTON, LIEUT. H. E., charge special records section, engineering department, engineering data and records, Naval Aircraft Factory, Navy Yard, *Philadelphia, Pa.*

FROSSEER, SAMUEL T. E., assistant works engineer, engine factory, Messrs. White & Poppe Ltd., *Coventry, England.*

PURDY, W. F. P., foreman of special tests laboratory, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*

QUINN, CHARLES J., purchasing dept., Curtiss Eng. Corp., *Garden City, L. I.*

RENTSCHLER, CAPTAIN F. B., A. S. A. P., Bureau of Aircraft, *New Brunswick, N. J.*

RICKLIN, PAUL J., engineer of production, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*

ROMAINE, W. L., secretary, manager Machine Tool Dept., Badger Packard Mch. Co., *Milwaukee, Wis.*

ROWLAND, GEORGE R., supervising engineer, The Texas Company, *New York City.*

SAKUYAMA, TRIKICH, designer, Premier Motor Corp., *Indianapolis, Ind.*

SANFORD, LIEUT. FRANCIS T., technical officer, Royal Air Force, R. A. C., Pall Mall, *London.*

SCHROEDER, E. O., engineering dept., Murphy Iron Works, *Detroit, Mich.*

SCHWAB, LOUIS, president, Stevens & Co., *New York City.*

SCHWABLE, A. G., director of purchases, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*

SCOFIELD, H. H., assistant inspection engineer, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*

STEINER, HUBBARD W., assistant engineer, The Standard Parts Co., *Cleveland, Ohio.*

SWAIN, WILLIAM L., foreman, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*

TULLAR, ROBERT J., chief draftsman, Naval Aircraft Factory, Navy Yard, *Philadelphia, Pa.*

VAN HUSAN, CORWIN, instructor in airplane mechanics, Air Service, *Detroit, Mich.*

WACKER, HERBERT E., foreman, Fisher Body Corp., *Detroit, Mich.*

WALLACE, D. A., mechanical engineer, Waterloo Gasoline Engine Co., *Waterloo, Iowa.*

WHEELER, ARTHUR W., machine shop superintendent, 1545 Dudley St., *Cincinnati, Ohio.*

WHITNEY, RAYNARD L., assistant experimental engineer, American La-France Fire Engine Co., *Elmira, N. Y.*

WILLIAMS, L. L., factory manager, engineer, The Lang Body Co., *Cleveland.*

WILSON, MARK LEONARD, draftsman, The White Motor Co., *Cleveland, Ohio.*

WINTER, H. L., assistant inspection engineer, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*

WINTERS, GEORGE W., chief instructor, service dept., War Education Dept., University of Cincinnati, *Cincinnati, Ohio.*

WITTEMAN, PAUL W., secretary, treasurer, managing director, consulting engineer, Wittemann Lewis Aircraft Co., *Newark, N. J.*

WITTKOWSKY, HENRY ROBERTS, designer, body engineer, Fisher Body Corp., *Detroit, Mich.*

WOOD, 2ND LIEUT. RUSHMORE, Air Service, A. E. F., *France.*

ZARNIKAN, HERMAN, general inspector, Curtiss Aeroplane & Motor Corp., *Buffalo, N. Y.*

Applicants Qualified

The following list of applicants have qualified for admission to the Society between Oct. 15 and Nov. 15, 1918. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (Aff. Rep.) Affiliate Representative; (S. E.) Student Enrollment.

ADAMS, WALTER OWEN (M) plant manager (mechanical and chemical engineer), Erie Specialty Co., 510 West Twelfth St., *Erie, Pa.*

ALTREE, ARTHUR H. D. (A) assistant treasurer and general sales manager, Bosch Magneto Co., Inc., 223-225 West Forty-sixth St., *New York City.*

ANSTED, FRANK B. (A) president, Lexington Motor Co., Eighteenth St. and Columbia Ave., *Connersville, Ind.*

BARBOUR, ROBERT (M) vice-president and consulting engineer, Parrett Tractor Co., Fisher Bldg., *Chicago.*

BARTHOLMEW, J. B. (M) president, Avery Co., *Peoria, Ill.*

BAYLOR, C. A. (A) general superintendent, Great Western Mfg Co., *LaPorte, Ind.*

BELL, LAWRENCE D. (J) factory manager, The Glenn L. Martin Co., 16800 St. Clair Ave., *Cleveland, Ohio.*

BRADLEY, S. S. (M) general manager, Manufacturers Aircraft Association, Inc., 501 Fifth Ave., *New York City.*

CAROLIN, CAPT. NORBERT (M) Air Service, Division of Military Aerodynamics, *Washington.*

CHANHOUSE, FRED S. (M) general superintendent, Sturtevant Aeroplane Co., *Jamaica Plain, Mass.*

CONGDON, CLEM H. (J) assistant naval constructor, Navy Department, *Washington.*

COOK, C. A. (J) sales engineer, Detroit Accessories Corp., 2021 Gratiot Ave., *Detroit, Mich.*

COOK, M. (A) secretary and general manager, Service Motor Truck Co., *Wabash, Ind.*

COPE, L. S. (M) metallurgist, Hoover Steel Ball Co., *Ann Arbor, Mich.*

DAVIS, CHARLES W. (A) chief engineer, The Torrington Co., Laurel St., *Torrington, Conn.*

DITTMANN, M. C. (M) vice-president and general manager, American Bronze Corp., *Berwyn, Pa.*

EDWARDS, JOSEPH B. (M) president and general manager, Kellogg Switchboard & Supply Co., Adams and Aberdeen Sts., *Chicago.*

EGGENWEILER, CHARLES W. (A) superintendent, General Aluminum & Brass Mfg. Co., 2512 East Grand Blvd., *Detroit, Mich.*

ELIASON, R. O. (A) mechanical draftsman, Engineering Bureau, Motor Equipment Section, *Washington.*

FISHER, W. H. (M) executive, Fisher Body Corp., Detroit, Mich.
 FITZGERALD, J. W. (Aff. Rep.) chief engineer, L. A. Young Industries, Inc., Detroit.
 GRUSS, A. G. (M) factory manager, Doehler Die Casting Co., Huntington and Court Sts., Brooklyn, N. Y.
 HAHN, E. A. (M) assistant engineer, Grant Motor Car Corp., Cleveland, Ohio.
 HARBECK, J. N. (M) president, Duesenberg Motors Corp., 120 Broadway, New York City.
 HECHT, E. A. (M) mechanical engineer, The Mansfield Tire & Rubber Co., Mansfield, Ohio.
 HOBBY, J. O., JR. (A) treasurer, American Locomotive Co., New York City.
 HOOPER, J. C. (J) sales representative, The Cincinnati Ball Crank Co., North St., Oakley, Cincinnati, Ohio.
 HUMMEL, W. H. (A) superintendent, Grant Motor Car Corp., Colt Road and Kirby Ave., Cleveland, Ohio.
 JACOBI, E. R. (A) supervisor of inspection, Mitchell Motors Co., 3606 Washington Ave., Racine, Wis.
 KELLER, EMIL E. (M) president, Standard Screw Products Co., Detroit, Mich.
 KRALUND, JOHN (M) factory manager, Doehler Die Casting Co., Huntington and Court Sts., Brooklyn, N. Y.
 LAYMAN, W. A. (M) president, Wagner Electric Mfg. Co., 6400 Plymouth Ave., St. Louis, Mo.
 LEWIS, I. M. (A) treasurer and manager, Bessemer Motor Truck Co., Grove City, Pa.
 McNAMARA, JOHN H. (M) plant manager, Curtiss Aeroplane & Motor Corp., Hammondsport, N. Y.
 MATHEWSON, E. T. (M) district engineer, S.K.F. Ball Bearing Co., Hartford, Conn.
 MEREDITH, ROY B. (M) ensign, 2233 Pickens Road, The Hill, Augusta, Ga.
 MOFFETT, CHARLES W. (M) general manager, Warren Machine Products Co., Warren, Pa.
 NEDOMA, CHARLES L. (A) technical secretary to vice-president, Cadillac Motor Car Co., 1343 Cass Ave., Detroit, Mich.
 NEWSON, DAVID J. (M) chief draftsman, aeronautical engineer, Canadian Aeroplanes, Ltd., Dufferin and Lappin Sts., Toronto, Ontario, Canada.
 NICHOLS, JOHN T. (M) chief engineer, motor department, secretary-treasurer, North American Motors Co., Chadwick Engineers Works, Pottstown, Pa.
 NOLTING, FREDERICK G. A. (A) buyer, Premier Motor Corp., Twentieth and Olney Sts., Indianapolis, Ind.
 ODEN, ERMUND D. (J) draftsman, Rutenber Motor Co., Marion, Ind.
 OTTE, OTTO M. (M) treasurer and general manager, Interior Metal Manufacturing Co., Jamestown, N. Y.
 POWELL, WALTER E. (M) general foreman of inspection tools, airplane engine division, Nordyke & Marmon Co., Indianapolis, Ind.
 QUINN, JOHN L. (M) district sales manager, Standard Oil Co., 1727 N. Spring St., Los Angeles, Cal.
 ROOT, O. J. (M) mechanical engineer and first vice-president, Root & Van Dervoort Engineering Co., East Moline, Ill.
 RUSSELL, HARTWELL B. (J) draftsman, Airplane Engineering Division, Bureau of Aircraft Production, McCook Field, Dayton, Ohio.
 SCHARFF, C. R. (A) traffic director, Chevrolet Motor Co., 1764 Broadway, New York City.
 SCHUEHLE, WALTER A. (M) aeronautical mechanical engineer, Airplane Engineering Division, Bureau of Aircraft Production, McCook Field, Dayton, Ohio.
 SEIBERLING, F. A. (M) president, The Goodyear Tire & Rubber Co., 1144 East Market St., Akron, Ohio.
 SIMMONS, C. F. (M) factory manager, Airplane Engineering Division, Bureau of Aircraft Production, McCook Field, Dayton, Ohio.
 SMITH, S. C. (A) service manager (technical service Packard Motor Car Co.), Stults Motor Co., 320 East Leith St., Fort Wayne, Ind.
 STENGER, E. P. (J) metallurgist, Sheldon Axle & Spring Co., Wilkes-Barre, Pa.
 STERN, LAWRENCE G. (M) supervisor of construction, Standard Aircraft Corp., Elizabeth, N. J.
 STOUGH, KENNETH K. (J) layout and detail draftsman, The Haynes Automobile Co., Kokomo, Ind.
 STURDEVANT, ARMYDIS E. (M) chief draftsman, Warner Gear Co., Muncie, Ind.
 TAYLOR, KENNETH S. (M) chief engineer, Ericson Mfg. Co., Buffalo, N. Y.
 TEETOR, CHARLES N. (M) general manager, The Indiana Piston Ring Co., Hagerstown, Ind.
 TWEEDY, O. S. (Aff. Rep.) vice-president and general manager, L. A. Young Industries Inc., Detroit.
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Book Reviews for S. A. E. Members

This section of THE JOURNAL contains notices of the technical books considered to be of interest to members of the Society. Such books will be described as soon as possible after their receipt, the purpose being to show the general nature of their contents and to give an estimate of their value.

AIRPLANE CHARACTERISTICS A systematic introduction for flyer and student and for all who are interested in aviation. By Frederick Bedell, Ph. D. Published by Taylor & Co., Ithaca, N. Y., 1918. Cloth, 6 by 9 in., 123 pp.

Dr. Frederick Bedell, professor in physics at Cornell University, has rendered valuable service in preparing Airplane Characteristics to serve as a systematic introduction to all interested in aviation. He points out that the principles of flight can in the main be set forth as definite and without surmise, and that a collection of the essential elements can now be made that will apply to all airplanes irrespective of type or structure.

The introductory discussion in this volume is a contribution to a codification which will prove useful not only to the flyer and designer, for whom the book is primarily intended, but to students and engineers and to others who have only a general interest in aviation.

The author has confined his attention to the principles of airplane flight and given no discussion of materials of construction, or of the gas engine.

It is planned that the book—with the added chapters now in preparation—shall be self-contained and complete in its own field, i.e., as an introduction.

The generalizations quoted below from the book are explained in a clear logical manner.

Experiments on the air resistance of different surfaces or bodies can be made in various ways. The necessary velocity of the body relative to the air can be obtained by dropping it from a suitable tower or other height (employed by Eiffel), by carrying it on a fast moving vehicle, by carrying it at the end of a long rotating arm (employed by Langley), by exposing it to a natural wind, and finally by carrying it through the air in airplane flight. The most convenient and approved method now in use is to expose the body to an artificial wind in a wind tunnel, first used by Eiffel and now used in all aerodynamic laboratories. Air is forced through such a tunnel by means of a powerful fan; the body to be studied is held stationary, being attached to suitable devices for measuring the pressure and, in case of oblique surfaces, for "weighing" the vertical as well as the horizontal component of the pressure. In such a tunnel can be tested not only surfaces or bodies of various kinds, including wing sections, but even complete airplanes in model size; and it is important to note that the performance of wings and airplanes in flight is found to agree remarkably well with wind-tunnel tests.

Air Pressure and Wings

When the plane is perpendicular to the air-stream, i.e., when the angle of incidence is 90 deg., the center of air pressure on the plane is at the center of the plane.

When the plane is oblique, the center of pressure is found to be in advance of the center of the plane, moving more and more forward toward the entering edge as the incidence decreases.

It is to be borne in mind that it is the downward deflection of the air that creates the lift, it being the purpose of the designer to increase this lift and at the same time to decrease the wing-resistance. Lift is obtained to a certain extent by the positive pressure on the lower surface of the wing, but to a much greater extent by the negative pressure on the upper surface; indeed, as much as three-fourths of the total lift may be due to this negative pressure.

It is the curvature of the upper surface of a wing that is most important—particularly its dip toward the entering edge, often referred to as the dipping front edge. The curvature of the lower surface is far less important; with a well-formed upper surface a good wing can be constructed with a perfectly flat lower surface. An upward turn in the lower surface toward the entering edge, corresponding to the dip in the upper surface, and making what is known as "Phillips entry," is not advantageous.

A cambered plane exerts a lift even at a small negative incidence. Zero lift is usually obtained when the incidence is between 2 and 4 deg., but in extreme cases the incidence may be decreased to 6 or 8 deg. before zero lift is reached. Although in most cases an airplane flies with a positive incidence, at high velocities it may fly with zero incidence or with a small negative incidence, but not within 2 or 3 deg. of the point of zero lift.

As the incidence is increased, the lift increases rather uniformly and reaches a maximum at an incidence of 14 deg. or so, according to the particular wing. Beyond this maximum, which is also known as the burble point, the lift decreases somewhat irregularly and again becomes zero at an incidence of about 90 deg. The upper limit of maximum lift is possible, but in ordinary flying it is only approached, for as it is approached there is danger of a stall due to increase of wing-resistance, leading to a fall or tail slide. With the decreased velocity which accompanies increased incidence, the stability of the machine becomes less and may vanish entirely; as the power of control depends upon velocity, the recovery of equilibrium when once lost at low speed is difficult. Too great an incidence is a frequent cause of accident. Exact limits cannot well be set; but, roughly speaking, the range of incidence is between 0 and 10 deg., limits which are never greatly exceeded in ordinary flight. There is, for each machine, a certain angle of incidence—well within these limits—at which the power required is a minimum. If the incidence is either increased or decreased, there is a very great increase in the amount of power required.

All cambered wings show a marked shifting of the center of pressure toward the rear of the plane, when the incidence is small and is decreasing—a bad feature for stability. In this one respect a cambered wing is inferior to a flat plane, in which the center of pressure moves forward when the incidence is decreasing.

Types of Wing

There is no one type of wing that is best. It will be understood that in different machines different wings may best be used, according to the particular features to be emphasized; high speed in one, large load-carrying capacity in another; stability in one, quickness in maneuvering in another, and so forth.

For speed, the wing should be flatter, with only a little camber, with less lift and with the least possible wing-resistance at small incidence and high velocity. It is necessary to sacrifice either speed or lift. Again, both speed and lift may be sacrificed for stability. The center of pressure on a cambered wing, convexed upward, shifts with change of incidence (when the angle of incidence is small) in the wrong direction for stability. If a cambered wing were concave downward—a very bad wing for lift—this shifting of the center of pressure would be in the right direction for stability. The two effects can be combined, in varying proportions, by giving a wing a double curvature.

The lift that supports an airplane is equal to the product of the area of wing, the square of the velocity, and a coefficient of lift that varies with the angle of incidence.

When the center of gravity is in front of the center of lift, there is a moment or couple tending to make the machine nose down; when the center of gravity is back of the center of lift, there is a couple tending to make the machine nose up.

The only possible way for changing the speed of a machine, or for getting different speeds in different machines, is by changing the loading or by changing the value of the coefficient of lift. In practice there are of course limits to both of these changes. The loading is commonly about 6 lb. per sq. ft., being less in slow machines and more (8 and even 10 lb.) in fast machines.

Some early machines had a very small speed range, let us say from a minimum of 35 to maximum of 50 m.p.h., giving a speed range of 15 m.p.h. A gust from behind of more than 15 m.p.h. would reduce the relative air speed below the requisite 35 m.p.h. necessary for sustenance, so that the machine had no support. This was one cause for the so-called holes in the air.

The lift curve for a wing is modified in a complete machine by whatever lift there is (either positive or negative) on other parts of the machine—body, tail and other surfaces—and, in a biplane or triplane, by an interference between the planes that reduces the lift. This reduction is less when the gap between the planes is large and when they are given considerable stagger than when the gap is small and there is no stagger. Lift likewise increases with aspect ratio, the ratio of wing span to chord.

With adjustable wing-area, the pilot would use large area for low speed and small area for high speed.

With adjustable camber, the pilot would use for low speed such camber as gave maximum lift. For high speed he would flatten out the wing and so get less lift without a dangerous reduction in incidence. This flattening of the wing would also bring about a reduction of wing-resistance—a highly important advantage of high speeds.

Power and Velocity

It has been shown that the velocity of a machine is dependent only upon incidence (ignoring the possibility of a change in wing-area or camber and the effect of altitude), incidence being controlled by the position of the elevator. It may well be asked: What about power? What effect upon velocity has the amount of power supplied by the engine? The answer is: The power supplied by the engine has no direct effect upon velocity, whatsoever; if the elevator is kept in one position without change, the same angle of incidence is maintained, and hence the same velocity, irrespective of the power supplied by the engine.

If the engine supplies just the right amount of power required to overcome the total air resistance, the machine flies horizontally. If it supplies more power, the machine takes an oblique path upward, the "surplus power" being used against gravity. If the engine supplies less power than is necessary to overcome resistance, the machine takes an oblique path downward, the necessary additional power being in this case supplied by gravity.

The angle of incidence—the angle between the chord and the relative air or flight path—being the same in the three cases, the velocity is the same irrespective of whether the flight path is horizontal or oblique; the power is increased or decreased by adjustment of the throttle, the inclination of the flight-path is changed, but (provided the elevator is not changed) the angle of incidence and velocity remain unchanged. Indeed, if the power is entirely cut off, the machine takes an oblique flightpath downward at a definite gliding angle, while the velocity still remains unchanged. The one way to change velocity is to change the angle of incidence by means of the elevator; furthermore, if horizontal flight is to be maintained, the throttle must be adjusted at the same time so that the amount of power required for horizontal flight is supplied by the engine—otherwise the flightpath will be oblique. An airplane is, in normal flight, practically a constant-speed machine, flying usually at the one velocity corresponding to a certain best angle of incidence for which the machine is designed.

It takes more power to fly at low speed or at high speed than at an intermediate speed. The amount of power required to maintain horizontal flight increases very rapidly when the velocity is either increased or decreased beyond a rather narrow range. Power, as well as stability, is, accordingly, a factor—in many cases a determining factor—in deciding the range of velocity and the limiting values for the angle of incidence and the coefficient of lift.

Parasite and Wing-Resistance

To get wing-resistance, it is merely necessary to divide the known weight by the L/D ratio, the value of this ratio being taken from a table or curve for the particular wing section. With increase of velocity (decrease of incidence) wing-resistance always decreases until a certain velocity is reached, after which it again increases. The minimum velocity for any wing-section is obtained at the critical angle of incidence; a greater angle of incidence is beyond the range of practical flight.

For a given wing-section there are three possible ways for changing wing-resistance—by changing the weight, the loading, or both. If the wing-section is varied, the number of possible variations is infinite. A wing that has high camber in order to secure great lift, also has large resistance, particularly at small angles of incidence; while a flatter wing with less camber and less lift is better adapted for high speed, having small resistance. But there are many intermediate forms and variations that make an interesting field for study. While about two-fifths of the power delivered through the propeller by the engine is used in pushing the wings through the air, three-fifths of the power, approximately, is used up in parasite resistance.

A large part of the resistance of a cylindrical strut or wire to motion through the air is due to the region of low pressure behind it. Only little is gained by tapering the front side of a cylinder or strut. Note the blunt breast and tapering tail of a bird, and the shape of a

fast swimming fish that can dart through the water with scarcely a ripple.

For low resistance, wheels and body should be enclosed; these, as well as every strut and wire, should be streamlined so far as they can be. It should be remembered that a small cylindrical wire may offer much more resistance than a larger wire that is well streamlined. Parasite resistance is roughly distributed about as follows: Body, one-third; wires and struts, one-third; tail and landing gear, one-third (about one-sixth for tail and one-sixth for landing gear).

The parasite resistance of the tail and all parts of the structure in the slip stream is increased, say, 50 per cent when the propeller is running. Approximate calculations can be made on this basis. Another approximate method is to consider that the increase of the total parasite resistance due to the propeller slip stream is 10 per cent.

In design every effort should be made to reduce weight and to cut down parasite resistance. The chief weight is in the engine and the reduction of weight is largely a problem for the engine designer. Reduction in parasite resistance is to be looked for in improved design of structure.

Stability

The line of flight is always understood to be the path of the center of gravity. Stability requires that a restoring moment be set up whenever the machine is displaced from its normal position. If the machine is rolled over to one side, with one wing raised and the other lowered, there must be a rolling moment tending to roll the machine back until the two wings are again on the same level. Although for steadiness in normal flight a certain positive lateral stability is desirable, for quick maneuvers a less positive or even an indifferent stability becomes advantageous. It can be noted that a gull, when it lowers its head as it flies near the water in search of fish, also droops its wings so as to make an inverted dihedral; in this way stability is secured with what is now a lowered axis. As the head is raised again for normal flight and the rolling axis changes from a lowered axis to a neutral and then to a raised axis the inverted dihedral (\wedge) may be seen to disappear and an upright dihedral (\vee) to take its place.

Retreating or swept back wings, with a raised rolling axis, give lateral stability, for when the machine rolls the descending wing moves forward and enters the air more squarely so as to attack more air and get more lift, thus restoring the machine to its position of equilibrium. Retreating wings and wings with raked ends (i.e., with trailing edge longer than entering edge) have the same effect as a dihedral angle upon lateral stability, but with the advantage that in a side gust they create no tendency for a machine to roll. All three devices—dihedral angle, retreating wings and raked ends—give directional stability. But they all have the disadvantage of reducing the so-called lifting efficiency.

Banking and Turning

Some machines are made so as to depend entirely upon banking as a means for turning, no rudder being provided. Conversely, turning produces banking and in some machines the rudder has been the only means for banking, no ailerons or similar devices being provided. There is room for difference of opinion as to how great an extent banking and turning should be automatically dependent upon each other and to what extent their control should depend upon the pilot.

In a machine with one propeller, as the propeller rotates in one direction there is a tendency (when the power is on) for the whole machine to rotate in the opposite direction. This can be easily corrected for in the control by the pilot, or automatically by a difference in the lift of the two wings. When flying, any correction is made by the pilot unconsciously. When starting, however, the correction may be noticeable, for the amount of correction changes as the engine accelerates; furthermore, it is particularly important while near the ground to keep both wings even.

Any lack of wing symmetry gives a tendency for the machine to rotate when power is off. In horizontal flight this can be corrected for by the controls, but in diving it may make a spin that cannot be controlled.

Although the keel surface is the chief element in directional stability, the wings may contribute. Directional stability is in all cases aided by retreating wings and by wings with a transverse dihedral angle, on account of the greater resistance of the wing which advances when the machine swings off from its course; this is independent of the location of the rolling axis. A rudder alone without a keel would be ineffective, for the machine when rotated by the rudder would tend to skid along its original flight path, as does a toboggan on smooth ice. A rudder is most effective when it is placed far back and the keel surface is placed near the center of gravity.

Turning causes banking, for two reasons: (1) The outer wing, having the higher velocity and greater lift, tends to rise, and the inner wing tends to descend on a turn; (2) the pressure on the keel surface on a turn tends to keel the machine over in the same direction as in (1), provided (as is usually the case) the keel center is above the rolling axis.

Turning causes increase of resistance and loss of speed due to the fact that the pressures on keel and rudder each have a backward component.

Turning causes a decrease in lift and a tendency to descend, i.e., a tendency to stall, for two reasons: (1) On account of loss of speed, the pressure on the wings, and hence the lift, is decreased; (2) on account of banking, the vertical component of the lift is decreased, this component becoming zero when a machine is banked 90 deg.

The tendency to stall on a turn can be overcome, if necessary, by maintaining speed either by putting on more power or by nosing down a little by means of the

elevator. Loss of speed is to be avoided. Obviously, to attempt to climb on a turn is dangerous.

If a machine is banked too much for a particular turn, it will slip in and down, on account of the horizontal component there is to the lift.

If a machine is not banked enough, it will skid out and (in some cases, due to the inertia of the machine) up.

With the proper banking, the centripetal force toward the center of the turn due to the banking must just equal the centrifugal force away from the center. There being no skidding or side slipping, the pilot will feel no side wind on either cheek. He will feel a pressure holding him to his seat with no pressure to left or right. Strings tied to guy-wires blow straight back and not at an angle. If rolling is indicated by an inclinometer like a level (arched upward) placed across the machine, the bubble remains central. In skidding or side slipping the machine leaves the bubble behind; the pilot ought to keep in mind that the control should follow the bubble. It is a good plan to start banking just before beginning a turn.

Gyroscopic Action

The propeller and revolving parts of the engine form a gyroscope, so that a sudden turn of the machine sideways will cause it to pitch or rear. Similarly any sudden pitching or rearing will cause the machine to turn to one side; for, when a sudden force is applied perpendicularly to the axis of a gyroscope, the axis swings sideways at right angles to that force. The direction of this effect will depend upon the direction of rotation of the revolving parts, and so may be opposite in different machines. This effect will be but small when controls are not jerked suddenly; indeed, these should not be operated suddenly on account of the severe stresses produced.

TIRE REPAIRING AND VULCANIZING By Henry H. Tufford. Published by Dunwoody Industrial Institute, Minneapolis, Minn. Cloth, 6 by 9 1/4 in., 98 pages, illus.

A practical booklet covering every detail of the work outlined in the title, and one which cannot fail to be useful in any repair shop. Repair fabrics are discussed. A scale for cutting has been compiled and included. Injuries, defects and abuses are clearly explained. In addition, a list of shop terms and of shop tools is given. The book is generously illustrated.



GOVERNMENT STANDARD GASOLINE AND OIL SPECIFICATIONS

THE Committee on Standardization of Petroleum Specifications recently adopted three specifications relative to the automotive industries. These cover aviation gasoline for export, fighting and domestic uses, motor gasoline and navy fuel, gas and bunker oils.

SPECIFICATIONS FOR AVIATION GASOLINE (EXPORT, FIGHTING AND DOMESTIC)

COLOR

The color shall be water white.

Test Inspection of a column in a standard 4-ounce oil-sample bottle.

FOREIGN MATTER

The gasoline shall be free from acid, undissolved water and suspended matter.

Acid Test The residue remaining in the flask after distillation is completed is shaken thoroughly with 1 cc. of distilled water. The aqueous extract must not be colored red on addition of a few drops of methyl-orange solution. Water and suspended matter would be in evidence in the test for color.

DOCTOR TEST

The gasoline shall yield a negative doctor test.

Preparation of Reagents

Sodium plumbeite or "doctor solution": Dissolve approximately 125 grams of sodium hydroxide ($NaOH$) in a liter of distilled water. Add 60 to 70 grams of litharge (PbO) and shake vigorously for 15 to 30 min., or let stand with occasional shaking for at least a day. Allow to settle and decant or siphon off the clear liquid. Filtration through a mat of asbestos may be employed if the solution does not settle clear. The solution should be kept in a bottle tightly stoppered with a cork.

Sulphur Obtain pure flowers of sulphur.

Making of Test

Shake vigorously together two volumes of gasoline and one volume of the "doctor solution" (10 cc. of gasoline and 5 cc. of "doctor solution" in an ordinary test tube; or proportional quantities in a 4-ounce oil-sample bottle may conveniently be used). After shaking for about 15 sec., a small pinch of flowers of sulphur should be added, the tube again shaken for 15 sec. and allowed to settle. The quantity of sulphur used should be such that practically all of the sulphur floats on the surface separating the gasoline from the "doctor solution."

Interpretation of Results

If the gasoline is discolored, or if the sulphur film is so dark that its yellow color is noticeably masked, the test shall be reported as positive and the gasoline condemned as "sour." If the liquid remains unchanged in color and if the sulphur film is bright yellow or only slightly discolored with gray or flecked with black, the test shall be reported negative and the gasoline considered "sweet."

CORROSION AND GUMMING TEST

The gasoline when subjected to the corrosion test shall show no gray or black corrosion and no weighable amount of gum.

Directions for Making Test

The apparatus used in this test consists of a freshly-polished hemispherical dish of spun copper, approximately $3\frac{1}{2}$ in. in diameter. Fill this dish to within $\frac{3}{8}$ in. of the top with the gasoline to be examined and place the dish upon a steam bath. Leave the dish on the steam bath until all volatile portions have disappeared.

If the gasoline contains any dissolved elementary sulphur, the bottom of the dish will be colored gray or black.

If the gasoline contains undesirable gum-forming constituents, there will be a weighable amount of gum

deposited on the dish.

Acid residues will show as gum in this test.

Interpretation of Results

It is specified that no gray or black deposit shall be formed. This wording is intended to admit gasolines that have so small a quantity of sulphur that the deposit is peacock colored.

It is specified that there shall be no weighable amount of gum. The intention is to refuse admittance to gasolines that show an amount that can be readily weighed in this style of dish.

The distillation method and apparatus shall conform to those outlined and described in Bureau of Mines Technical Paper No. 166, entitled "Motor Gasoline, Properties, Laboratory Methods of Testing and Practical Specifications."

VOLATILITY AND DISTILLATION RANGE

Export Grade

When 5 per cent of the sample has been recovered in the graduated receiver the thermometer shall not read more than 65 deg. C. (149 deg. Fahr.), or less than 50 deg. C. (122 deg. Fahr.).

When 50 per cent has been recovered in the receiver the thermometer shall not read more than 95 deg. C. (203 deg. Fahr.).

When 90 per cent has been recovered in the receiver the thermometer shall not read more than 125 deg. C. (257 deg. Fahr.).

When 96 per cent has been recovered in the receiver the thermometer shall not read more than 150 deg. C. (302 deg. Fahr.) and the end point shall not exceed this temperature by more than 15 deg. C. (27 deg. Fahr.).

At least 96 per cent must be recovered in the receiver from the distillation.

The distillation loss shall not exceed 2 per cent when the residue in the flask is cooled and added to the distillate in the receiver.

Fighting Grade

When 5 per cent of the sample has been recovered in the graduated receiver the thermometer shall not read more than 70 deg. C. (158 deg. Fahr.) or less than 60 deg. C. (140 deg. Fahr.).

When 50 per cent has been recovered in the receiver the thermometer shall not read more than 95 deg. C. (203 deg. Fahr.).

When 90 per cent has been recovered in the receiver the thermometer shall not read more than 113 deg. C. (235 deg. Fahr.).

When 96 per cent has been recovered in the receiver the thermometer shall not read more than 125 deg. C. (257 deg. Fahr.) and the end point shall not exceed this temperature by more than 15 deg. C. (27 deg. Fahr.).

At least 96 per cent must be recovered in the receiver from the distillation.

The distillation loss shall not exceed 2 per cent when the residue in the flask is cooled and added to the distillate in the receiver.

The United States War Department requires the fighting grade to be colored red after inspection and acceptance.

Domestic Grade

When 5 per cent of the sample has been recovered in the graduated receiver the thermometer shall not read more than 75 deg. C. (167 deg. Fahr.), or less than 50 deg. C. (122 deg. Fahr.).

When 50 per cent has been recovered in the receiver the thermometer shall not read more than 105 deg. C. (221 deg. Fahr.).

When 90 per cent has been recovered in the receiver the thermometer shall not read more than 155 deg. C. (311 deg. Fahr.).

When 96 per cent has been recovered in the receiver the thermometer shall not read more than 175 deg. C. (347 deg. Fahr.).

At least 96 per cent must be recovered in the receiver from the distillation. The distillation loss shall not exceed 2 per cent when the residue in the flask is cooled and added to the distillate in the receiver.

SPECIFICATIONS FOR MOTOR GASOLINE QUALITY

Gasoline to be high grade, refined and free from water and all impurities, and have a vapor tension not greater than 10 lb. per sq. in. at 100 deg. Fahr. temperature, same to be determined in accordance with the current "Rules and Regulations for the Transportation of Explosives and other Dangerous Articles by Freight"—paragraph 1824 (k)—as issued by the Interstate Commerce Commission.

INSPECTION AND TESTS

Inspection

Before acceptance the gasoline will be inspected. Samples of each lot will be taken at random. These samples immediately after drawing will be retained in a clean, absolutely tight closed vessel and a sample for test taken from the mixture in this vessel directly into the test vessel.

Test

100 c.c. will be taken as a test sample. The apparatus and method of conducting the distillation test shall be that described in Bureau of Mines Technical Paper No. 166, Motor Gasoline.

Boiling point must not be higher than 60 deg. C. (140 deg. Fahr.).

20 per cent of the sample must distill below 105 deg. C. (221 deg. Fahr.).

45 per cent must distill below 135 deg. C. (275 deg. Fahr.).

90 per cent must distill below 180 deg. C. (356 deg. Fahr.).

The end or dry point of distillation must not be higher than 220 deg. C. (428 deg. Fahr.).

Not less than 95 per cent of the liquid will be recovered from the distillation.

SPECIFICATIONS FOR FUEL, GAS AND BUNKER OILS

METHODS OF TEST

Flash-point will be taken as indicated in the specifications.

Viscosity will be taken by the Engler viscosimeter. (See note under Specifications)

Water and sediment will be taken by the distillation method. When oil in small lots is consigned to Naval vessels or to Navy Yards the centrifuge test will be used in order to obviate delay. In this test 30 c.c. of oil and an equal quantity of best commercial benzol, 50 per cent white, will be used, and the mixture heated to 100 deg. Fahr.

SPECIFICATIONS

Fuel oil shall be a hydrocarbon oil free from grit, acid and fibrous or other foreign matter likely to clog or injure the burners or valves. If required by the Navy Department, it shall be strained by being drawn through filters of wire gauze having sixteen meshes to

the inch. The clearance through the strainer shall be at least twice the area of the suction pipe and strainers shall be in duplicate.

The unit of quantity to be the barrel of 42 gal. of 231 cu. in. at a standard temperature of 60 deg. Fahr. For every decrease or increase of temperature of 10 deg. Fahr. (or proportion thereof) from the standard 0.4 per cent (or prorated percentage) shall be added or deducted from the measured or gaged quantity for correction.

The flash-point shall not be lower than 150 deg. Fahr. as a minimum (Abel or Pennsky-Marten's closed cup) or 175 deg. Fahr. (Tagliabue open cup). In case of oils having a viscosity greater than 8 Engler at 150 deg. Fahr. the flash-point (closed cup) shall not be below the temperature at which the oil has a viscosity of 8 Engler.

Viscosity shall not be greater than 40 Engler at 70 deg. Fahr. Water and sediment not over 1 per cent. If in excess of 1 per cent, the excess to be subtracted from the volume; or the oil may be rejected.

Sulphur not over 1.5 per cent.

Note If the Engler viscosimeter is not available, the Saybolt standard universal viscosimeter may be used.

Equivalent viscosities

8 Engler..... 300 sec. Saybolt

40 Engler..... 1500 sec. Saybolt

SPECIAL SPECIFICATIONS FOR GAS OIL FOR DIESEL ENGINES

Flash-point not lower than 150 deg. Fahr. (Abel or Pennsky-Marten's closed cup).

Water and sediment, trace only.

Asphaltum, none.

BUNKER OIL A

To comply strictly with the provisions for Navy specifications fuel oil, except that there shall be no limit on sulphur.

BUNKER OIL B

Specifications to be the same as for Navy fuel oil except:

The flash-point shall not be lower than 150 deg. Fahr. as a minimum (Abel or Pennsky-Marten's closed cup) or 175 deg. Fahr. (Tagliabue open cup). Rest of paragraph omitted.

Omit paragraph on viscosity and substitute "To have a minimum gravity of 15 Baumé."

Omit paragraph on sulphur requirements.

Navy standard fuel oil only will be supplied to battleships, destroyers and other vessels subject to heavy forced draft conditions or required to run smokeless. It will also be supplied for cargo oil for all shipments abroad or to Navy storage.

Bunker oil A will be used by other types of vessels requiring a light oil and by shore stations fitted with separate storage for yard use. It will not be used where Bunker oil B can be satisfactorily used.

Bunker oil B will be used by all transports and cargo vessels which can satisfactorily burn an oil not heavier than 15 Baumé.

The Commander, Cruiser and Transport Force, or his representative, and the District Supervisor, Naval Overseas Transportation Service shall determine the grade of oil to be used by vessels operating under their direction.

COMPLETING MILITARY HIGHWAY WORK

IN miles of concrete road between Alexandria and Camp Humphreys, Va., will soon be ready for use, marking the completion of planning and supervisory work done by engineers of the Bureau of Public Roads of the U. S. Department of Agriculture for the military authorities. The road from Alexandria to Camp Humphreys is the longest military highway outside of cantonments that has been planned and supervised by engineers of the

Bureau, although the total construction planned and supervised by these engineers aggregates several hundred miles and covers practically all the recognized types of construction, from sand clay to first-class bituminous surfaces and concrete roads. Seventeen highway engineers and one superintendent of construction were detailed to military work by the Bureau in July, 1917, the period of their assignments varying from 3 to 15 months.

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

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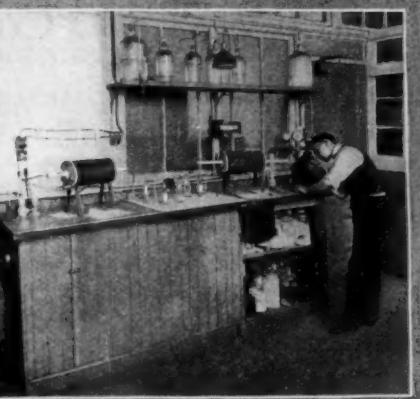
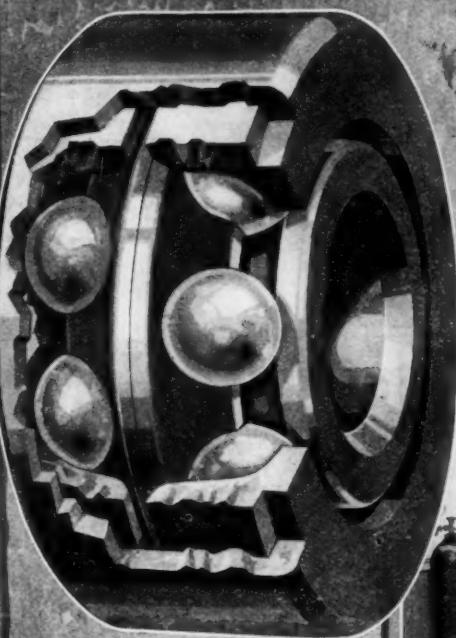
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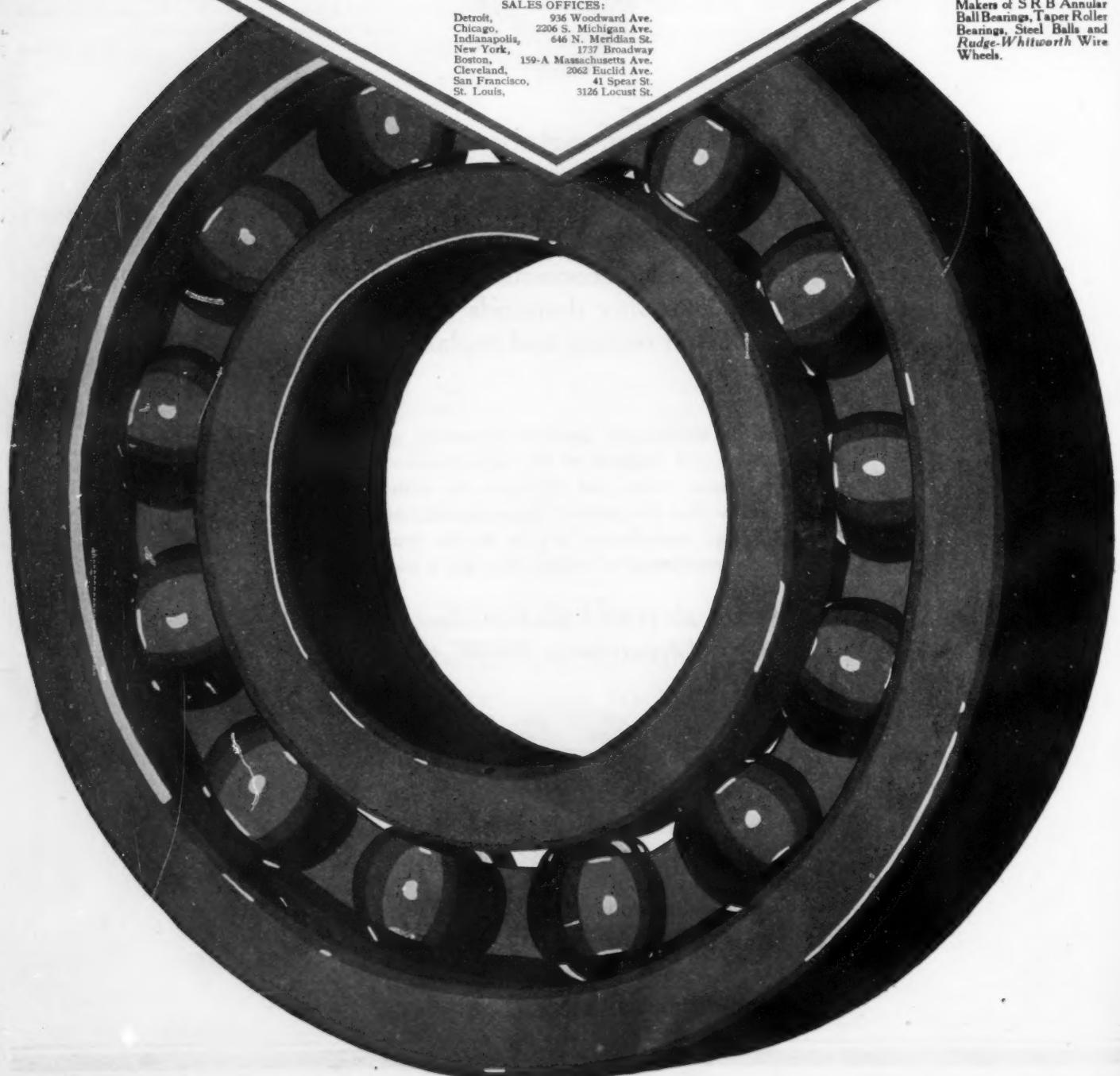
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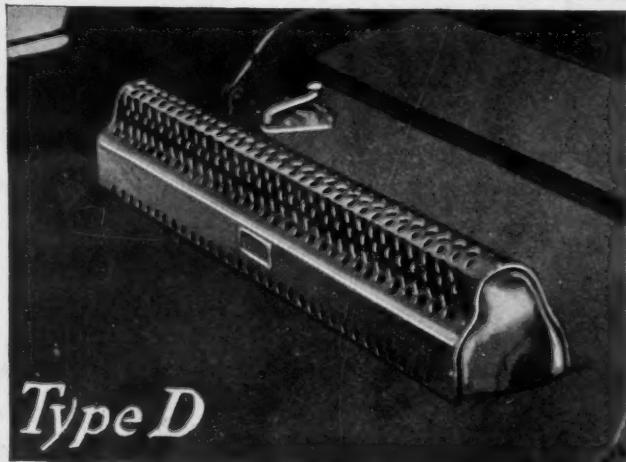
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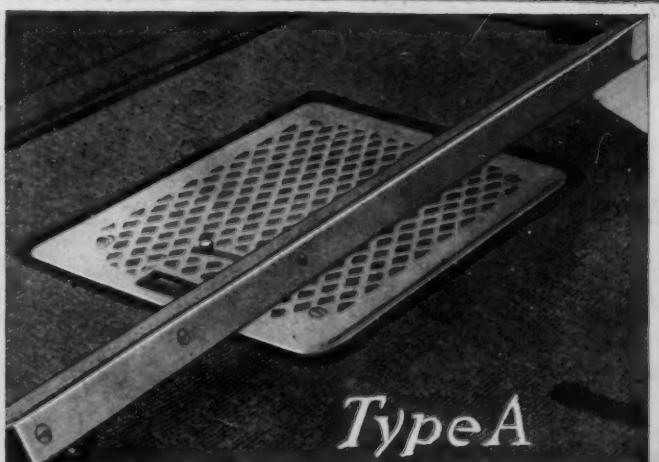
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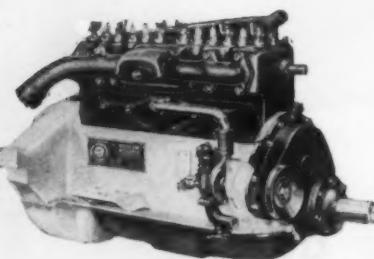
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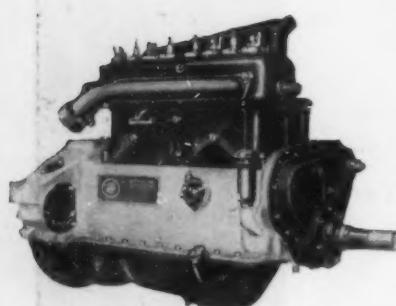


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They know what this famous motor will do—know they can rely on it for power, for economy, for speed, for silence, for durability, for every motor quality. They look upon the Red Seal as a guarantee against motor experiments.

The most convincing evidence of what a motor *will do*, is the record of what it *has done*, and in this we find the reason why the public believes so implicitly in the Continental Red Seal motor. Fifteen years of successful performance in hundreds of thousands of trucks and cars provides sure evidence of its worth.

Striking endorsement of this confidence of the public in the Continental, is seen in the fact that today over 160 vehicle manufacturers use it in one or more models of their trucks and automobiles. Thus upon it they stake the success of their product and an investment of many millions of dollars.

When you buy a truck or automobile look for the Continental Red Seal on the motor—the mark of proved worth.

CONTINENTAL MOTORS CORPORATION

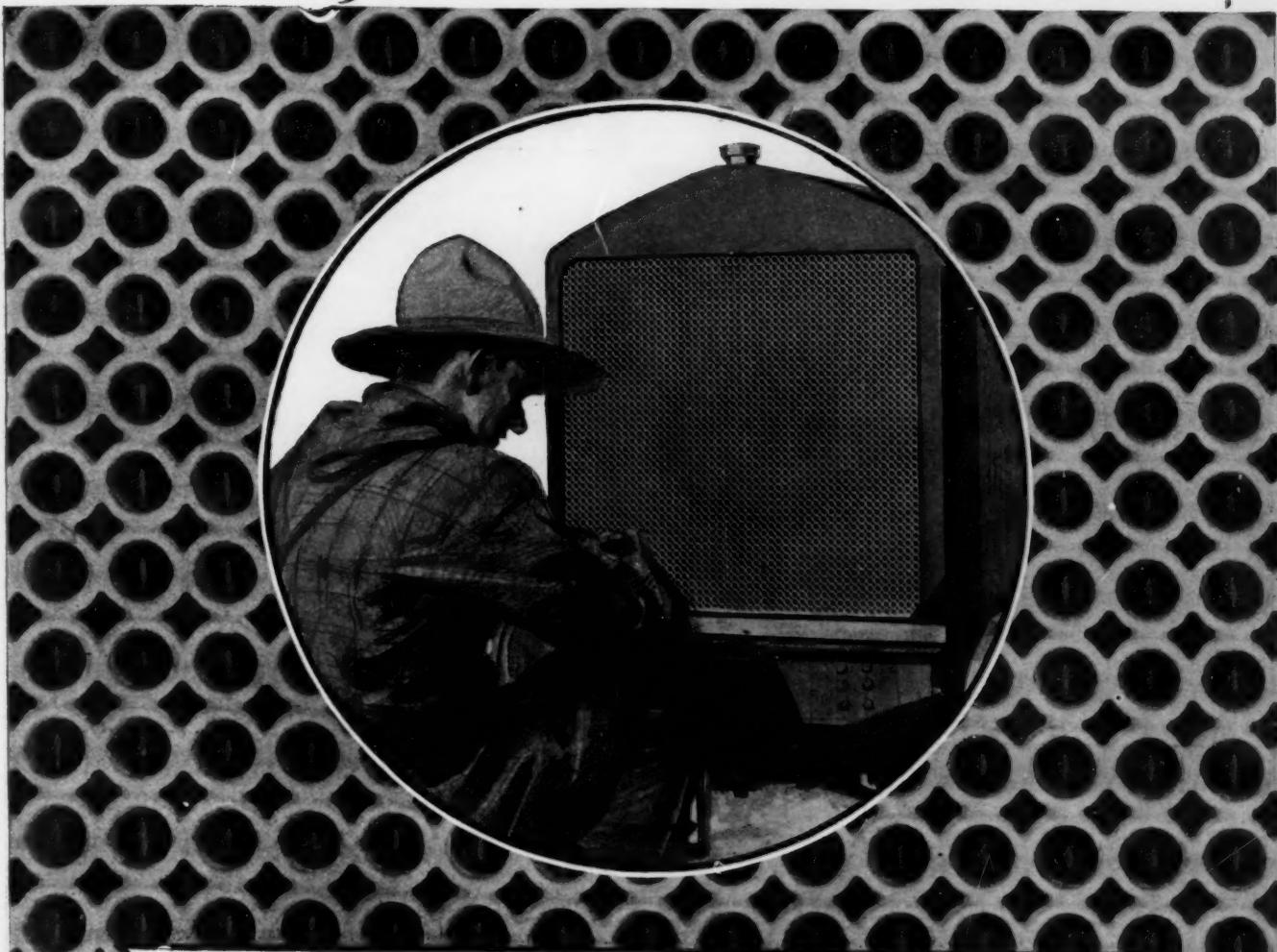
Offices:
Detroit, Michigan

Factories:
Detroit—Muskegon

Largest Exclusive Motor Manufacturers in the World

Continental Motors

AMERICA'S STANDARD POWER FOR TRUCKS AND AUTOMOBILES



PERFEX

The Perfect Radiator

Settles the "Durability" Question!

THE durability of a cooling system on a tractor is today a vital question. A delicate inefficient radiator may mean much time and money lost to user and manufacturer.

The number of years the ordinary radiator will last cannot safely be estimated in a laboratory. Actual service in the field is the only source of an accurate estimate.

But the big underlying principles of Perfex construction *can* be analyzed in the laboratory.

A study of the *Perfex* exclusive "Expansion Slit" quickly shows why it provides the necessary "flexibility" to absorb shocks.

The heavy, deep, bonded facings are far superior to ordinary methods of lap jointing.

extra large, unobstructed water channels insure perfect cooling. No fins, no clogging—every inch of surface cools.

The important thing to remember about the *Perfex* is that it cools and it *lasts*.

Our engineers will gladly confer with you relative to engine cooling problems. We are equipped to design and build a special *Perfex* for any Tractor, Truck or Motor Car.

Your correspondence is invited.

PERFEX RADIATOR CO.
770 Flett Ave., Racine, Wisconsin



100% American

TO THE MANUFACTURER today 100% Americanism is both a duty and a privilege.

Every resource of the Splitdorf organization—every factory, every machine, every workman, every ounce of material and equipment—is now and will continue to be devoted to a single purpose: to supply the needs of War and of the essential industries that are helping to win the War.

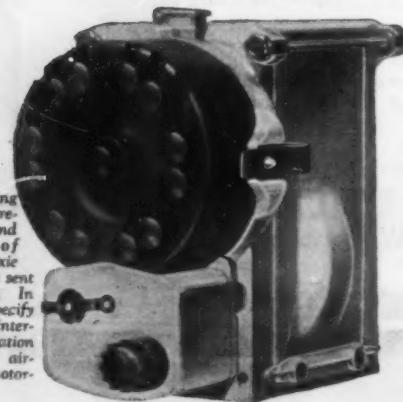
On the fighting fronts in France, Belgium and Italy, the magneto is relied upon to furnish the *vital spark* that drives airplane, tank, truck, tractor, motorcycle and automobile. As the pioneer ALL-AMERICAN manufacturer of magnetos, the Splitdorf Electrical Company is devoting all its engineering skill and factory facilities to the increased production of *standardized Dixie magnetos* for gasoline engines of every type from one to sixteen cylinders.

That this essential industry may never be called on in vain, loyal American producers in the acres of Splitdorf factories are working night and day. Volume production will continue until America and her Allies have secured the peace of the world.

Efficiency as never before; co-operation in intensified measure; production of essential equipment only; this is, has been and shall continue to be the war-time policy of the Splitdorf organization.

SPLITDORF ELECTRICAL COMPANY, Newark, New Jersey

Standardized Dixie
Magneto for 12-cylinder
airplane engine



To men in
the Service

Booklets containing full information regarding the care and maintenance of Standardized Dixie Magnetos will be sent free on request. In writing, kindly specify whether you are interested in the operation of magneto for airplane, truck or motorcycle.

DIXIE

All American MAGNETO



Driving Strains and Road Vibrations

The strains encountered by the driving members of a motor truck, together with the heat generated, invariably produce shaft deflections, and very often gear expansion.

The resultant discrepancies, which would ordinarily create undue friction, are fully compensated for by the self-aligning feature of SKF Ball Bearings.

The illustration above shows an SKF-equipped Schacht Truck. SKF Ball Bearings are used on the Worm Drive as a protection against the consequences of driving strains and road vibrations.

They are the choice of many other truck makers whose demands are for absolute reliability.

SKF BALL BEARING CO.
HARTFORD 487 CONN.

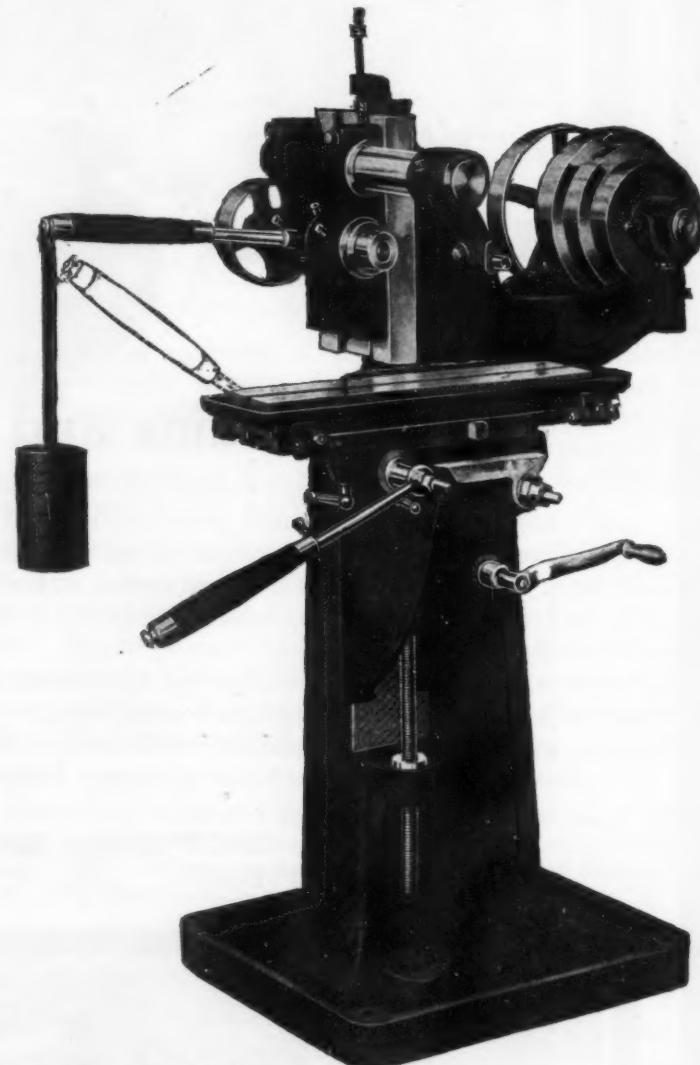


THE “WHITNEY” HAND MILLING MACHINE THOUSANDS IN USE

Invaluable in the **LARGE FACTORY**, as no other design equals it for big production on interchangeable work, as proved by the thousands of these machines in constant use both here and abroad. One concern alone is using over 700 of these machines, and many other concerns have over one hundred each.

Invaluable in the **SMALL SHOP**, as it will handle a wide variety of operations with convenience, accuracy and rapidity.

Order one now. It will soon pay for itself.



PROMPT DELIVERIES

THE WHITNEY MFG. CO., Hartford, Conn.

CHAINS

KEYS AND CUTTERS

HAND MILLING MACHINES

What has Cleaning to do with the making of a Car?

THE cleaning of materials, parts and units in the process of manufacture is a necessary and vital factor in automotive industries.

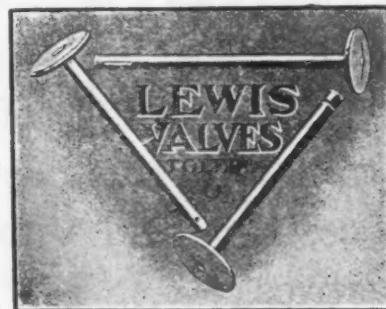
It is truly an essential operation, as necessary as machining or any other step, to the final product.

THE FACT that a large majority of the large manufacturers of automobiles, aeroplanes and accessories in this country have continued to use OAKITE and our other products for so many years, shows that they have recognized our materials to be effective and economical.

They are taking advantage of the knowledge obtained from innumerable records of practical results, systematized and backed up by scientific experimental work.

Cleaning IS an essential operation and OAKITE is essential for Cleaning

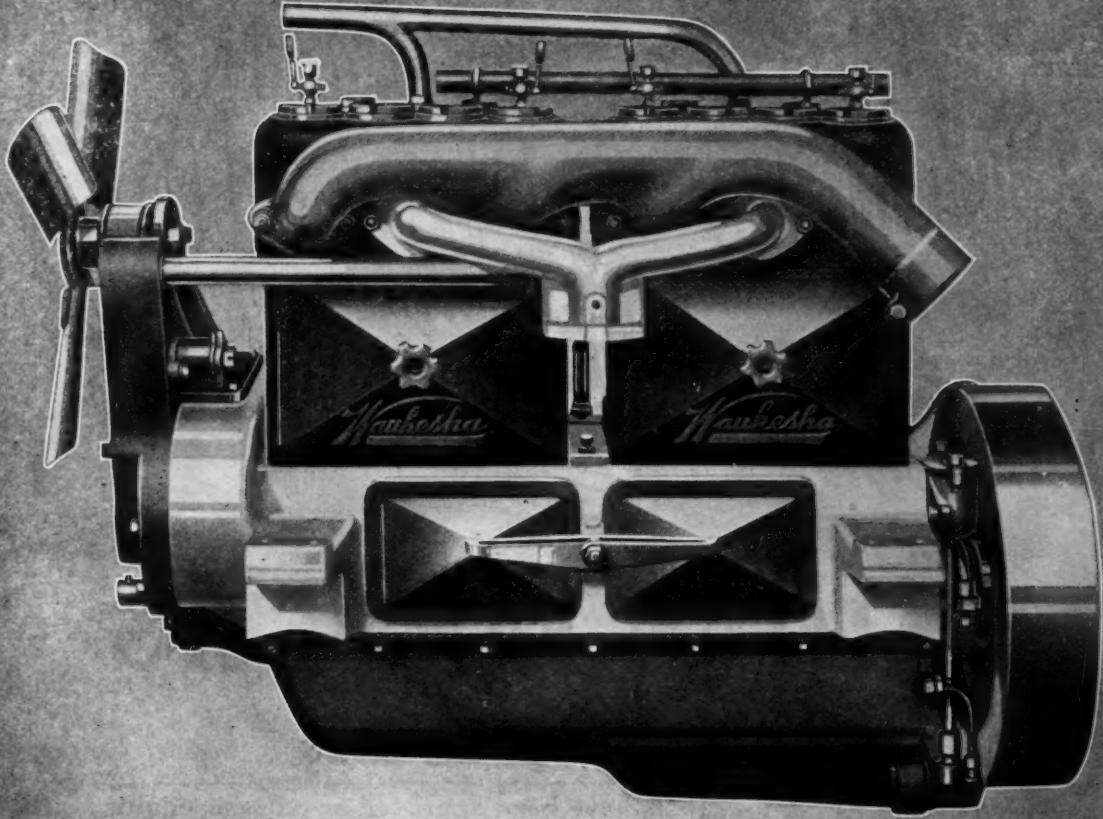
OAKITE MANUFACTURED BY
OAKLEY CHEMICAL CO.
36 THAMES STREET · NEW YORK



LEWIS VALVES

The Lewis Semi-Steel Valve has convinced others of its superior merits. Why not let it prove to you its worth? It tells its own story by giving you less valve trouble; consequently saving fuel for the user of your motor and making your customer satisfied.

THE LEWIS STEEL PRODUCTS CO.
4080 Detroit Ave.
TOLEDO, OHIO



Confirmed

Gas engine building during the period of war—here and abroad—has adhered closely to Waukesha engineering practice. It has confirmed the soundness of the theory embodied in

Waukesha
TRADE MARK

Four-Cylinder Motors for Trucks and Tractors

The four-cylinder, four-cycle principle has been used in all Waukesha Heavy Duty Motors from the beginning. Even the intensive study and research incident to the building of super-powered engines of war has not evolved better practice.

WAUKESHA MOTOR CO., Waukesha, Wis.
World's Largest Builders of Truck and Tractor Motors Exclusively



SPARTAN FAN BELTS

Doing Their Bit

Spartan Flat Leather Fan Belts have been approved as efficient equipment on the leading makes of motor trucks. They have met every specification and in practical use have proven supreme in the efficient transmission of motor truck power.

Spartan Flat Leather Fan Belts are made from leather of a special tannage, which insures great flexibility, unusual pulley grip and ability to resist unfavorable operating conditions. The leather used is the highest quality, cut from the center portion of the hide. They are thoroughly stretched, of even thickness and put together with cement which resists exposure to conditions quickly destructive to ordinary belt cement.

Spartan Fan Belts are cooling motors day in and day out under the most severe strains to which a belt may be subjected. They are operating efficiently "over there"—and "over here"—wherever in use, the utmost service results.

Send for booklet, "Spartan Fan Belts for Motor and Generator Drives."

THE GRATON & KNIGHT MFG. CO.

Makers of Flat Leather Belting, "V" Belting, Solid Block and Link Types
Leather Packings, Specialties, Etc.

Worcester, Mass.

Bennett KEROSENE CARBURETOR

The Kerosene Tractor Is Here

THE success of the tractor industry depends upon the success of the kerosene tractor. The high price of other fuels makes the kerosene tractor a necessity. Tractor buyers demand it.

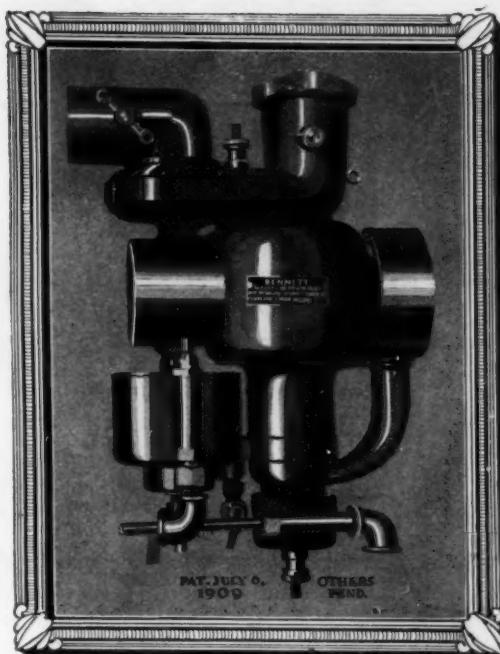
The kerosene tractor is different from the gasoline tractor.

The slower combustibility of kerosene demands different heat conditions—a different mixture—in other words, a different engine and a DIFFERENT CARBURETOR.

A gasoline carburetor "re-hashed" will not vaporize kerosene successfully. Unvaporized kerosene cuts out the lubricating oil and wears out the motor.

An attempt to use a makeshift carburetor means the failure of the tractor; the loss of the customer to the dealer; the loss of the dealer to the manufacturer; the loss of the manufacturer's good reputation.

The leading tractor manufacturers have already recognized the first principle of



success and are using the Bennett Kerosene Carburetor.

Bennett Carburetor Air Cleaner

DUST and sand are the cause of 90% of the internal troubles of all tractors. The Bennett Carburetor Air Cleaner removes dust and sand from air before it enters the carburetor. This prevents cutting out of bearings, pistons and rings, thus lengthening the life and efficiency of the motor. 40,000 now in use. Write for information.

**WILCOX-BENNETT
CARBURETOR CO.**
Specialists in Kerosene Carburetors

Minneapolis

The Bennett Carburetor



Air Cleaner

RICH TOOL COMPANY

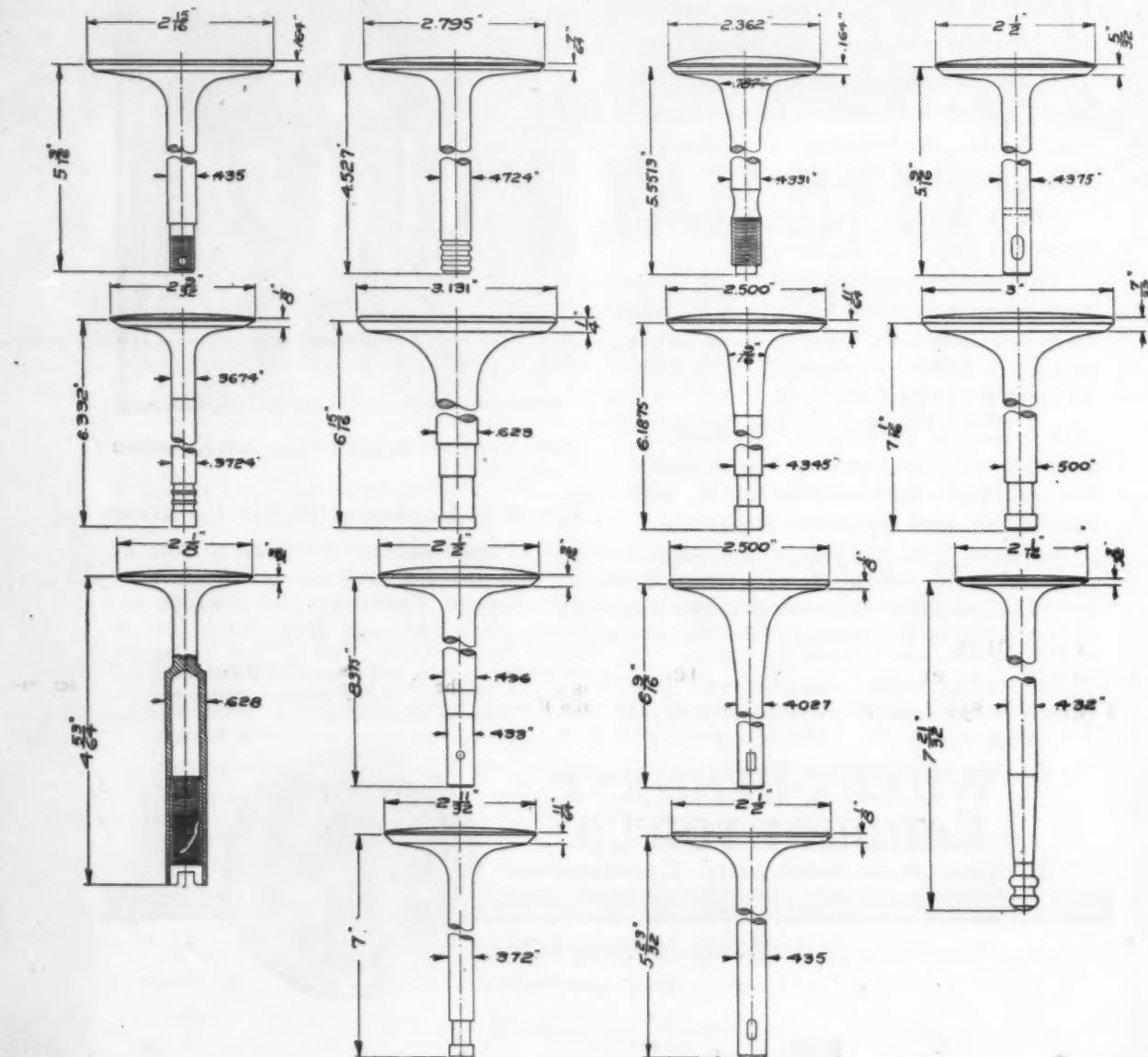
Kresge Building, Detroit, Mich.

Railway Exchange Bldg., Chicago, Ill.

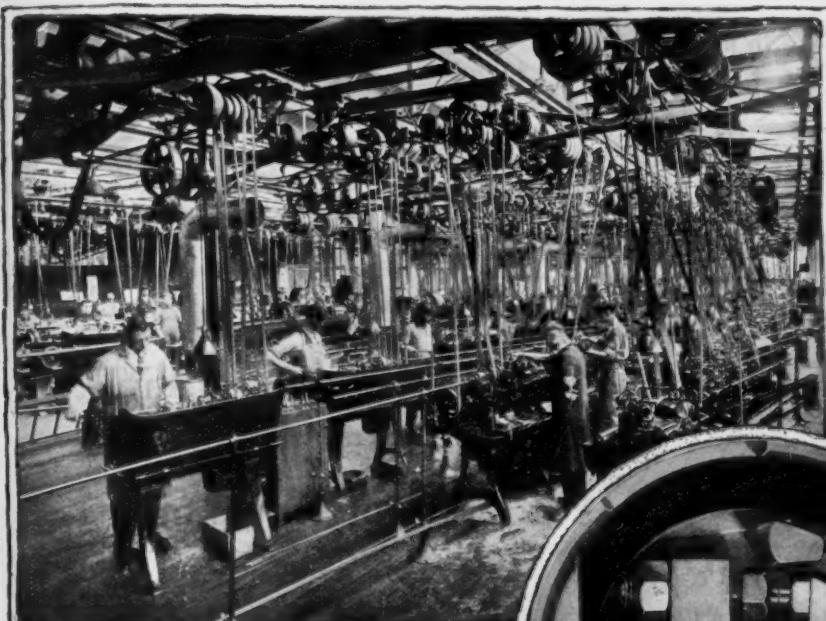
The cuts below represent valves used in some of the best known present day Aeroplane, Motor-Boat and Racing Automobile Engines. They are all products of this company and most of them have been produced in large quantities and have, therefore, been thoroughly tested in service.

Needless to say, they are all Tungsten Steel, but we also make one-piece forged valves of all other commonly used Alloy Steels in the manufacture of which we exercise the same care as is used in higher priced Tungsten Valve materials.

One of the newer types of valves which we have been making in very large quantities for the past year is our Hi-Chromium Valve, which has some very remarkable properties. It is for some purposes an excellent valve and we solicit inquiries from those who are troubled by a persistent burning away of the seats of the valves in their motors.



Our Engineering Department is at your service on all
questions concerning suitability of material and design.

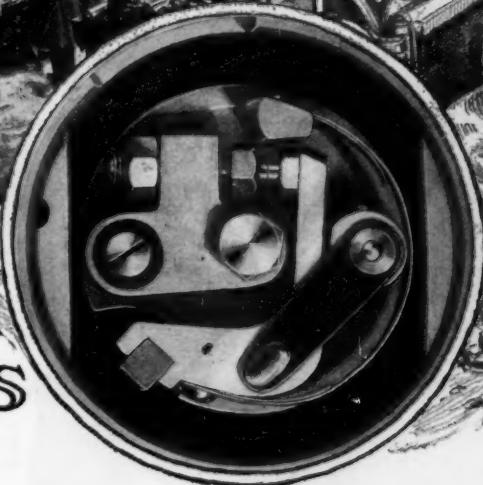


Bosch Interrupters Assure Absolute Synchronism

EVERY ignition system depends upon the efficiency of its interrupter or contact breaker.

The final results obtained from the engine are determined largely by the synchronism, speed, accuracy, longevity and spark intensity of its ignition system, which in time are determined by the precision with which the interrupter performs its exacting functions.

The Bosch Interrupter is unsurpassed for precision; it is the result of two decades of ignition study. That its design is ideal is proved by the fact that it is the prototype of practically all contact breakers in use today. It is a standard of the world.



The Bosch Interrupter meets successfully every condition that ignition systems have to face. It is wonderfully balanced; it will operate at any angle; centrifugal forces work in harmony with it; even at the highest speeds contact is made and broken perfectly and sharply; no strong springs are needed; the liberal platinum points used are not hammered or wasted.

Its solid construction includes, besides watch-like workmanship, the use of the finest material, carefully fashioned into a well-balanced perfectly functioning mechanism of lasting strength and service. It requires no oiling or other regular attention.

As the Keystone of an ignition system, the Bosch Interrupter is typical of the high ideals embodied in the unit it serves—the Bosch Magneto, America's Supreme Ignition System.

To assure the air of quality and confidence, equip your products with Bosch Magneto Ignition.

CORRESPONDENCE INVITED

Be Satisfied

Specify Bosch

BOSCH MAGNETO COMPANY

230 West 46th Street, New York

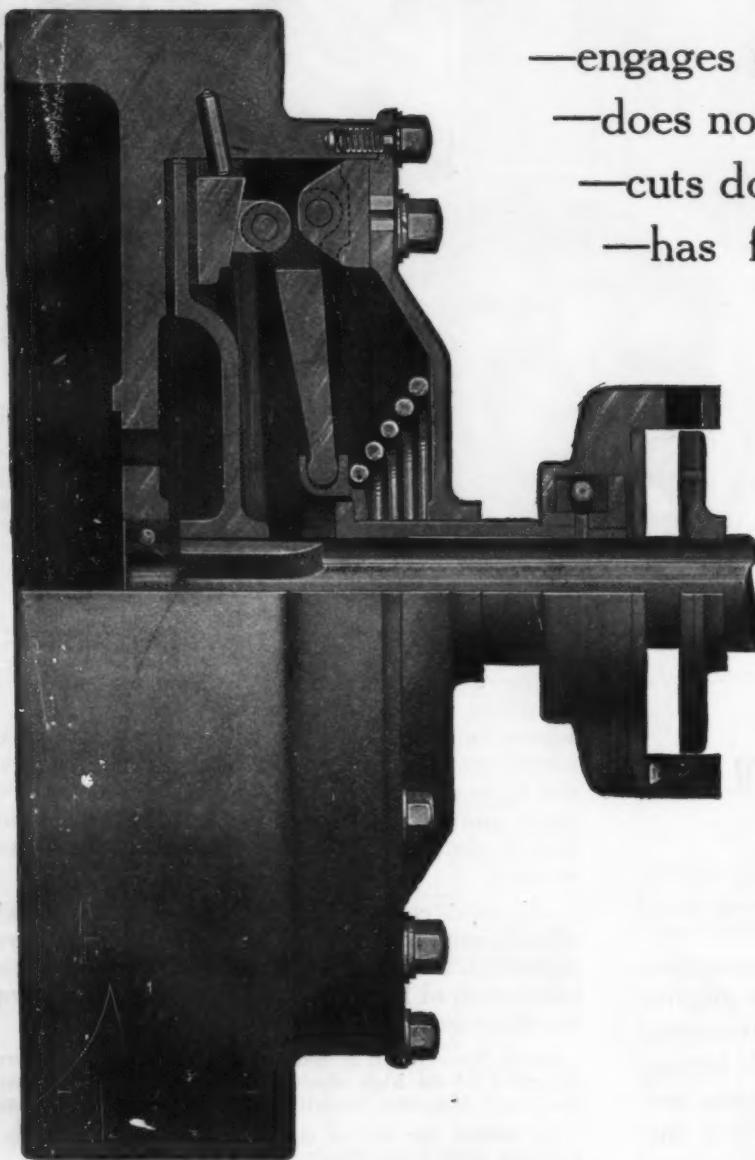
Branches: Chicago, Detroit, San Francisco

Works and Foundries: Springfield, Mass.

BOSCH
AMERICA'S SUPREME IGNITION SYSTEM
MOTOR TRUCKS - TRACTORS - AIRPLANES - MOTOR CARS - MOTOR BOATS - MOTORCYCLES - GAS ENGINES - ETC.

BORG & BECK

Single Plate Dry Clutch



- engages gradually
- does not grab, stutter or slip
- cuts down gear shifting
- has fool-proof adjustment

The *merits* of this clutch have made it standard in the *truck*, *tractor* and *automobile* industry—over 200,000 now in use—by over 150 leading manufacturers

Furnished to fit all standard motors and unit power transmissions.

THE BORG & BECK COMPANY
MOLINE, ILL.
Largest exclusive clutch manufacturers



Most Miles per Dollar

FIRST

Truck users naturally think of Firestone Tire equipment *first*, because Firestone is and always has been *first* in this field, from the earliest inventions and improvements in solid truck tires to the latest developments in giant cord tires. That is why

Over half the truck tonnage of America is carried on

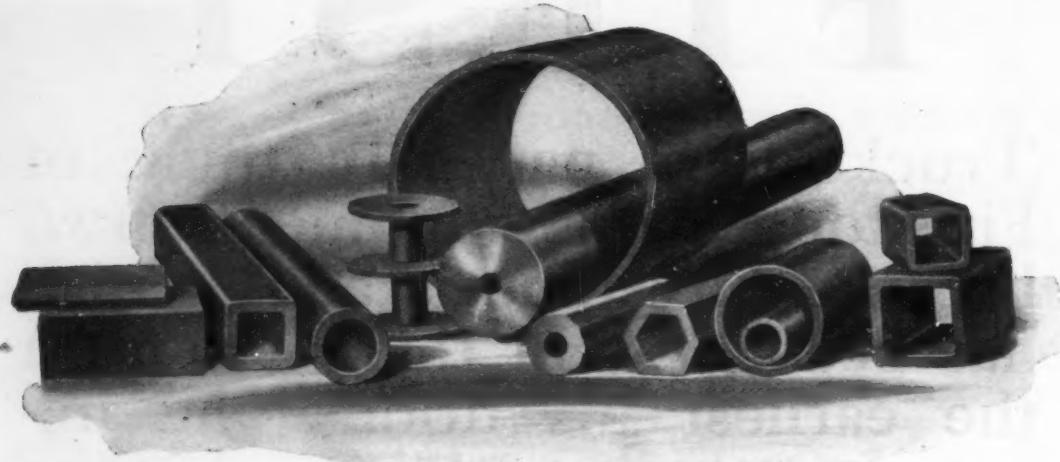
Firestone
Truck Tires

FIRESTONE TIRE & RUBBER COMPANY
FIRESTONE PARK, AKRON, OHIO

BRANCHES AND DEALERS EVERYWHERE

BAKELITE

REG. U. S. PAT. OFF.



These Sheets, Tubes and Rods Save Moulding

SOME of the most complex electrical and mechanical articles have been machined or punched from the many varied stock sizes of Bakelite Sheet, Tube and Rod.

These convenient forms of Bakelite afford the manufacturer who does not wish to incur the expense of making special moulds an opportunity to take advantage of the superior insulating and physical properties and easy machining qualities of Bakelite at a very nominal cost.

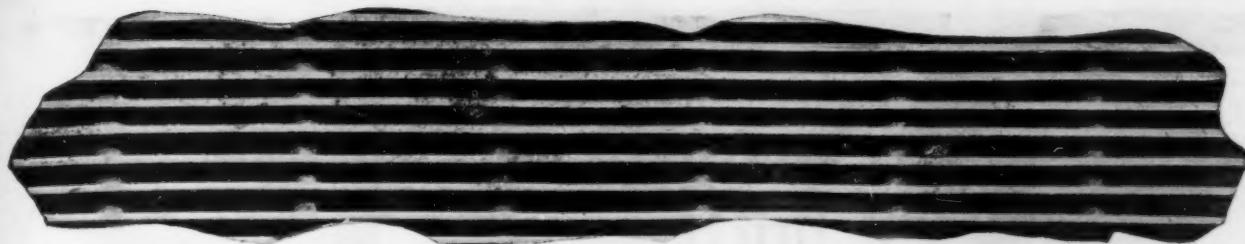
Bakelite Sheet, Tube and Rod possesses even greater mechanical and dielectric strength than Bakelite Moulded Insulation. It is unaffected by water, steam, oils, solvents and most chemicals and will not bloom or swell.

Orders for these forms of Bakelite should be directed to either the

CONTINENTAL FIBRE COMPANY
Newark, Delaware

WESTINGHOUSE ELECTRIC & MFG. CO.
East Pittsburgh, Pa.

The **GENERAL BAKELITE COMPANY**, 2 Rector Street, New York, welcomes inquiries from manufacturers and maintains a research laboratory for the working out of new applications.



Truck and Tractor Radiator Types

Free air circulation as afforded by the continuous fin tubular radiator is of prime importance in radiator efficiency

IN the continuous fin tubular radiator the maximum volume of cold air is forced over the finely distributed metal in order to absorb the greatest possible volume of the heat.

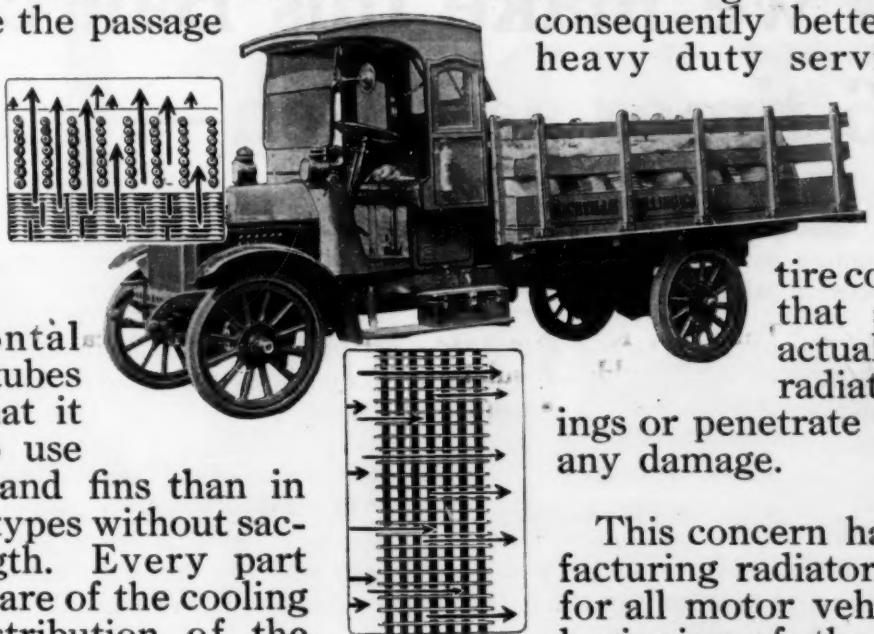
This type of radiator excels in this regard because the passage of the air is unimpeded and the tubes and fins are so thin that the heat is easily taken off.

The horizontal fins brace the tubes so securely that it is possible to use lighter tubes and fins than in other tubular types without sacrificing strength. Every part does its full share of the cooling since the distribution of the metal is uniform over every cubic inch of the core.

This means that greater efficiency is secured from every ounce of metal

used than in any other form of radiator.

However, with this thinly distributed metal, there is no sacrifice of strength in the continuous fin tubular core. The "bracing" is so perfect that this type of core is stronger than any other and consequently better adapted to heavy duty service.



The stress of a blow is distributed over the entire core. This means that a blow must actually break the radiator frame castings or penetrate the core to do any damage.

This concern has been manufacturing radiators of all types for all motor vehicles since the beginning of the motor car industry. Our knowledge of radiator construction is placed at the disposal of the manufacturers. That is the object of these discussions.

MC CORD MANUFACTURING COMPANY, INC., DETROIT, MICHIGAN



How we make this Ball carry 26 times as much—

Look at the steel raceway that supports this steel ball. Observe how its contour closely follows the curvature of the ball. Notice the area of contact between ball and raceway.

This steel ball, because of this close and accurate raceway-contour, will safely carry twenty-six times as much load as the same ball rolling on a flat surface.

This is one reason for the large load capacity of Gurney Ball Bearings and this large load capacity is the reason why Gurney Bearings are used by such Companies as General Electric, Westinghouse, Allis Chalmers, J. G. Brill, Otis Elevator, Lodge & Shipley, Pratt & Whitney, Brown & Sharpe, Pierce-Arrow, Franklin, Hupp, Haynes, Fordson, and many others almost as well known.

Gurney Ball Bearing Company
Conrad Patent Licensee
Jamestown, N. Y.

The Control of Quality

Point No. 15

The True Source of Accuracy

At every step in the control of quality, Timken accuracy is checked.

With his own gauge the grinder assures himself of the accuracy of every piece of work before it goes on to the inspector.

He knows that his gauge is correct because in the frequent comparisons with the master gauge in the tool-room even slight variations would be detected.

But even the tool-room standards might wear in time, and affect the work of the whole shop.

So a carefully guarded set of Swedish standard gauges is kept as the real basis of Timken accuracy.

These gauges—turned out at the factory of C. E. Johanssen in Sweden—are accurate to the limit of human ability. And they are kept locked in a vault, away from all influences that might have even the slightest effect on them.

Such gauges might not be necessary if only ordinary standards were maintained, but they are essential to the control of Timken Bearing Quality.

Swedish gauges are the acknowledged standard of accuracy. With their aid a Timken expert sets the tool-room micrometers to the ten-thousandth part of an inch.



THE TIMKEN ROLLER BEARING COMPANY
Canton, Ohio



TIMKEN BEARINGS



PHILBRIN

Reliable
IGNITION



100% ACCESSIBILITY

REMOVE the distributor cap of a PHILBRIN System and at once you reveal the entire mechanism of the instrument. Nothing is hidden. Every part is 100% accessible.

Now study the mechanism itself. Simple, isn't it? Aside from an adjusting screw, there is only one moving part—a tiny bar

of hardened steel which could never possibly wear out or cause trouble in the service it performs.

The correctness of PHILBRIN design and the dependability of Philbrin construction have been repeatedly and clearly established by recent comparative tests of importance.

Heretofore our entire output of Philbrin Systems of Ignition was required for war purposes but sample systems can now be furnished manufacturers for testing. Literature upon request.

PHILBRIN

TRADE MARK
IGNITION
SPECIALISTS

PHILIPS-BRINTON CO. KENNEDY SQUARE, PA.



Photo by Fox Pictures Service

STAMINA



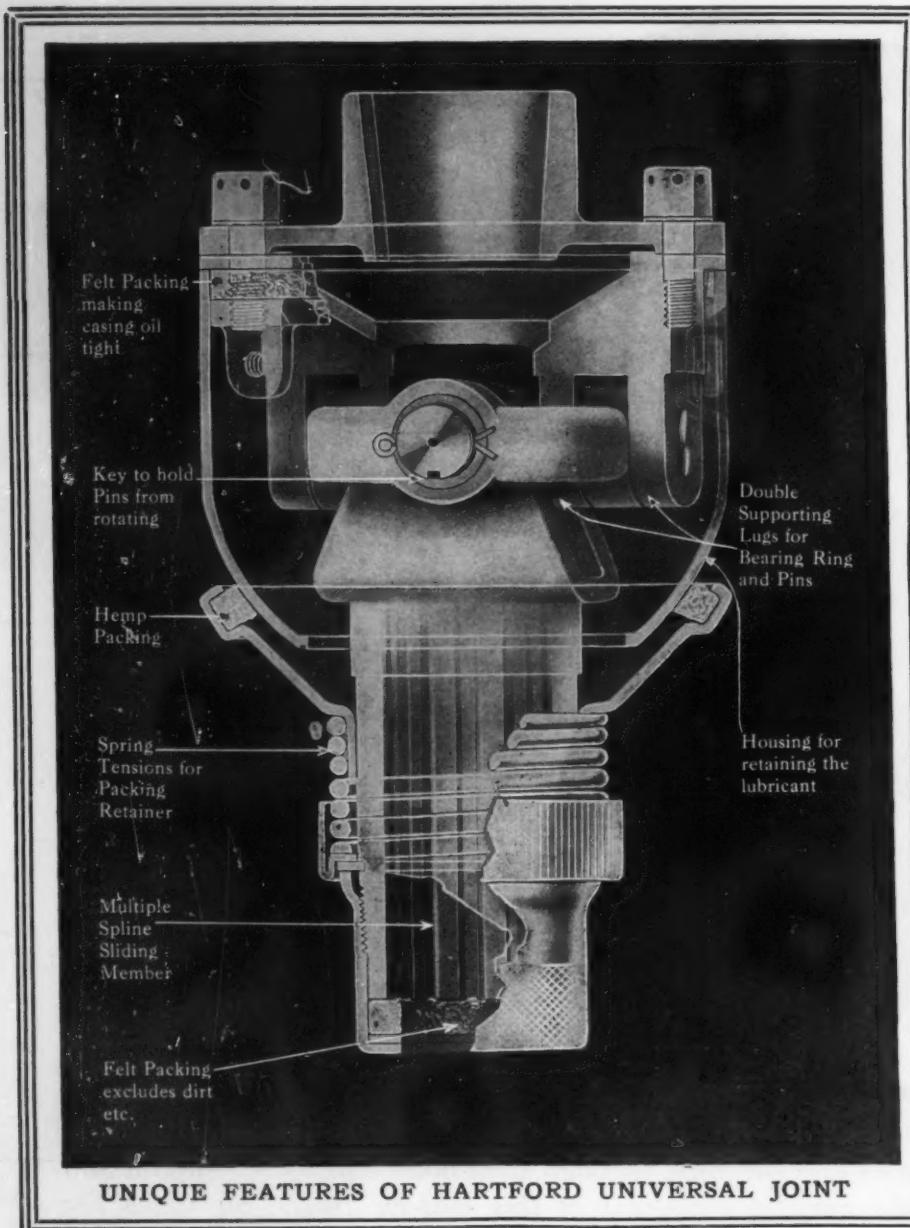
Tanks must have *stamina*. The wrench and strain of the cumbersome twists and turnings, through shell-holes and forest—uphill and down—the everyday evolutions of this modern fighter, on which life itself depended—bring into play forces of shock and vibration that test to the limit the *stamina* of every detail. Ignition must *not* fail—motor or ignition must *not* go dead through faulty connections or poor insulation.

Parts molded of CONDENSITE will *not* fail through any service—cause short of the shattering impact of machine-gun bullets! For CONDENSITE has *stamina*—a hidden stamina that enables this molded insulation to resist mechanical and electrical stresses, heat, oils, acid and other corrosive solvents. The best makers of American and foreign automobiles as well as leading electrical apparatus manufacturers and users have found CONDENSITE parts best meet their requirements because actual service has proved this *stamina*.

Small parts as well as large, for tank, airplane or "lorry," simple or complicated, can be *molded of Condensite in a single operation* with an accuracy that rivals the results attainable by many operations of an expert machinist. Why not discuss its use with the Condensite Research Organization?

Condensite Company of America
Bloomfield, New Jersey

2026



UNIQUE FEATURES OF HARTFORD UNIVERSAL JOINT

HARTFORD UNIVERSAL JOINTS

impress experienced engineers with the simplicity of their design. Unnecessary parts have been eliminated. Lightness is secured without sacrificing strength.

Bearings are self-oiling and hold lubricant sufficient for three to four thousand miles.

All parts are absolutely interchangeable and finished with the highest degree of scientific accuracy, the limits being within one-thousandth of an inch.

The outside casing is held in close contact with the inner casing, making it unnecessary to take up wear on the packing by tightening lock-nuts from time to time. Study these desirable Hartford features in the illustration.

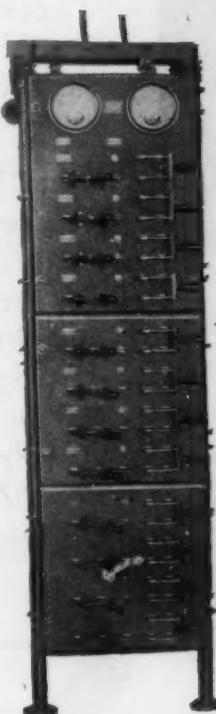
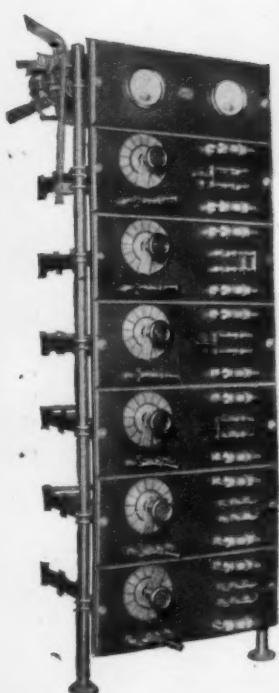
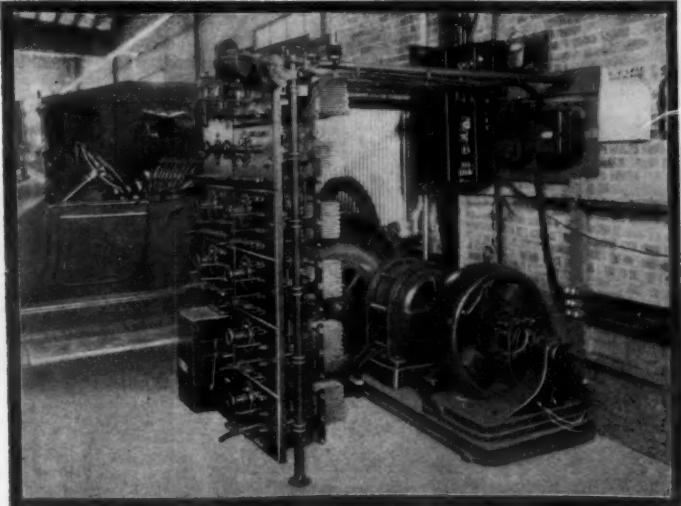
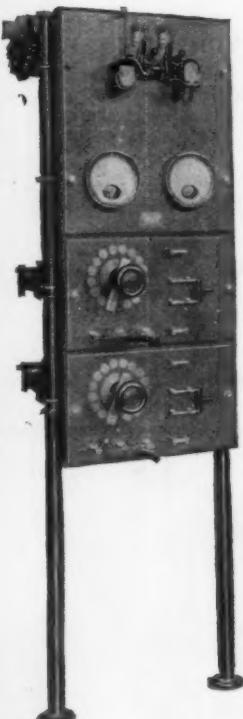


HARTFORD CONE CLUTCHES

have high grade leather facing accurately turned to size after assembling and are provided under the front edge with six flat springs having adjustable tension to allow the clutch to pick up the load gradually without the usual jerk. The disengaging mechanism and the clutch spring thrust are fitted with a ball thrust bearing and completely protected from dust and dirt. Clutch is furnished complete with double universal joint to compensate for misalignment between engine and transmission.

**HARTFORD AUTO PARTS CO.
HARTFORD, CONN.**

Hartford



Electric Vehicle Battery Charging

It is possible to charge a vehicle battery through a bank of lamps—or a big resistance. But it is slow and inefficient.

The Public Garage must be ready to charge any type of car quickly and at a reasonable power cost.

The Private Garage in a manufacturing plant or department store has definite types of cars to charge and can secure equipment which will be simple and yet give maximum efficiency.

The General Electric Company has studied hundreds of such problems. A few of the charging boards recently furnished are illustrated on this page.

Complete equipments include charging panels, control and motor generator sets—are selected for the special requirements of the purchaser.

When you have a Garage Problem—ask the nearest G-E Office to put you in touch with our engineers.

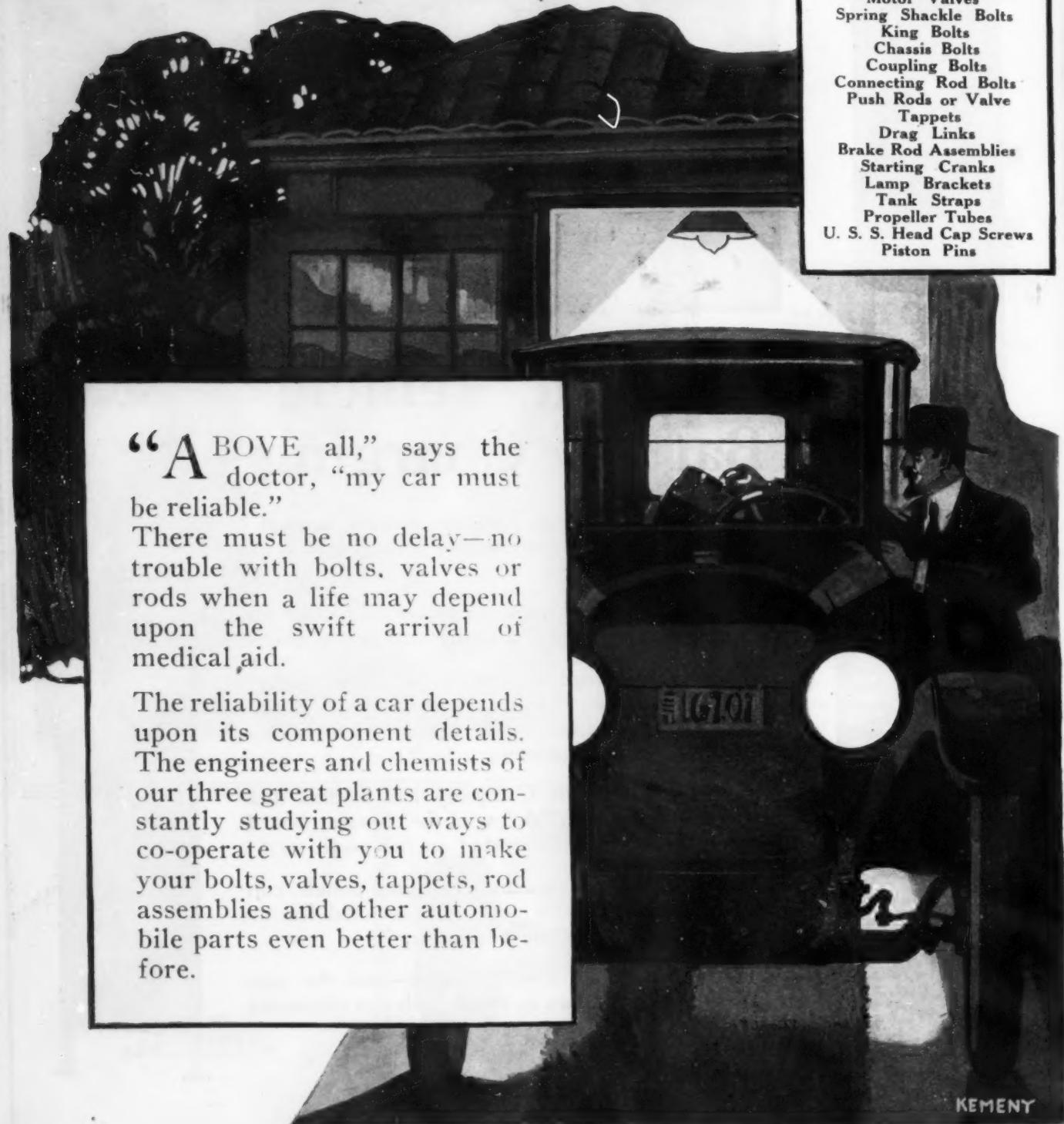


General Electric Company

General Office: Schenectady, N. Y.

Sales offices in all large cities

The Doctor's Car



A DEPARTMENT OF
YOUR PLANT FOR

Motor Valves
Spring Shackle Bolts
King Bolts
Chassis Bolts
Coupling Bolts
Connecting Rod Bolts
Push Rods or Valve
Tappets
Drag Links
Brake Rod Assemblies
Starting Cranks
Lamp Brackets
Tank Straps
Propeller Tubes
U. S. S. Head Cap Screws
Piston Pins

"ABOVE all," says the doctor, "my car must be reliable."

There must be no delay—no trouble with bolts, valves or rods when a life may depend upon the swift arrival of medical aid.

The reliability of a car depends upon its component details. The engineers and chemists of our three great plants are constantly studying out ways to co-operate with you to make your bolts, valves, tappets, rod assemblies and other automobile parts even better than before.

KEMENT

The Steel Products Co.

Michigan Plant
Detroit, Mich.

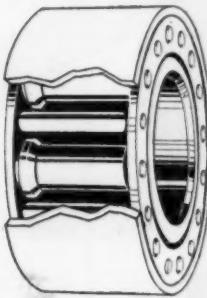
Main Plant
Cleveland, O.

Metals Welding Plant
Cleveland, O.



*Bearings That Cut Down
Operating Expense*

When a truck is equipped with Bower Roller Bearings up-keep cost is reduced to the minimum. Because the roller is of maximum diameter, and because radial and end thrusts are borne by separate surfaces, the wear in Bower Roller Bearings is reduced to the minimum. Consequently, no time need be lost in making adjustments. In the case of trucks, where a minute's delay oftentimes means dollars of loss, this is an important item.



BOWER
ROLLER BEARING CO.
Detroit Michigan

Gas, Oil and Water Tanks

FOR

Trucks and Tractors

DRAWN STEEL LOCK-SEAMED



BUILT UP OUT OF TERNE PLATE



"REINFORCT" WELD CONSTRUCTION



STAMPED UP IN TWO HALVES AND SEAMED



COATED AFTER STAMPING

when combined with prompt deliveries, greater production of all types and sizes, and satisfaction, mean—

G.P.&F. SERVICE
"KNOWING HOW SINCE '81"

Now when any increase in floor space means difficulties in obtaining building material and labor, delays in obtaining government priorities, the fact that we can produce a product corresponding favorably to your own product both in quality and in price means increased war effectiveness.

Our service is backed by an organization whose buying and manufacturing facilities are practically unlimited, a plant covering 15 acres of ground, and an experience in all phases of tank manufacturing methods extending over a period of 36 years.

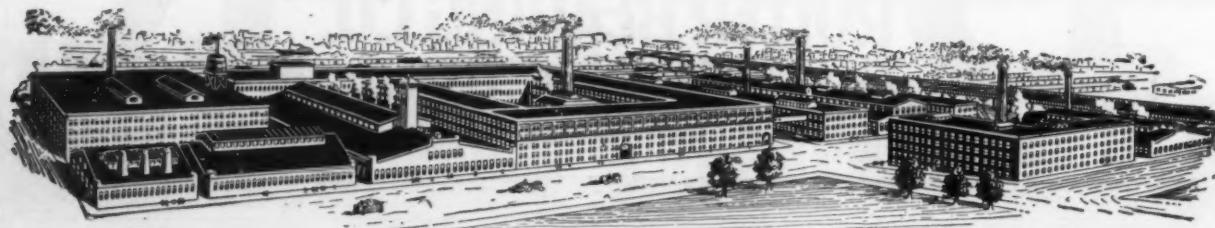
Send us your blue prints or specifications of your tanks and let us submit figures. You will be assured of the best possible product made exactly to your specifications.

Geuder, Paeschke & Frey Co.

1422-1700 St. Paul Avenue

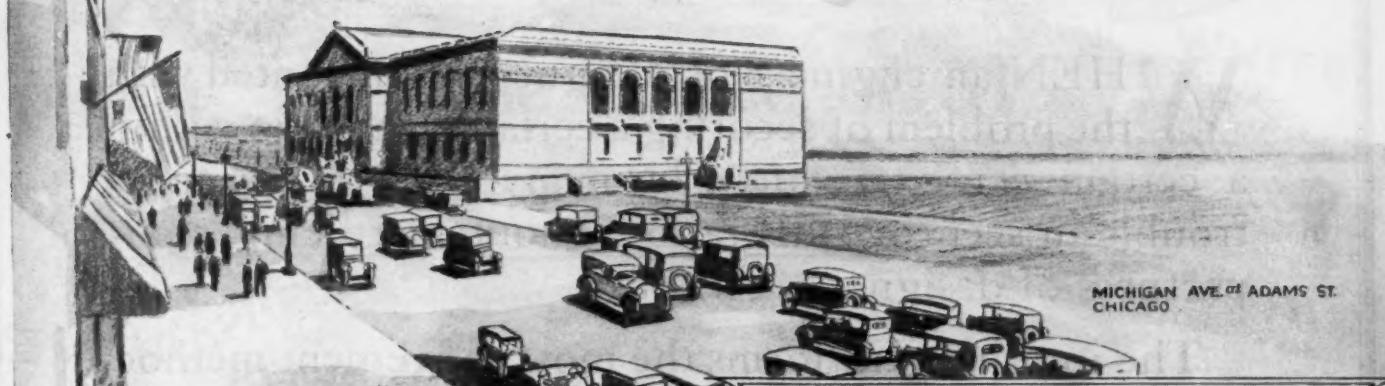
Milwaukee, Wis.

Makers ALSO of the Maxim Silencer



WOOD WHEELS

for MOTOR VEHICLES



Absolutely free from flaws or defects

When a hickory wheel leaves the factory it is a perfect wheel.

It has no flaws or weak spots.

This perfection of product is due, partly at least, to the fact that any defect in a billet of hickory is at once apparent.

The rigid system of inspection maintained in every wheel factory brings these flaws to light and every defective piece of hickory is at once discarded.

Manufacturers and users of passenger automobiles can feel absolutely safe when cars are equipped with strong, tough, resilient hickory wheels. For the many inspections to which they are subjected during manufacture insures them against all hidden weak spots.

AUTOMOTIVE WOOD WHEEL
& MANUFACTURERS ASSOCIATION
105 NORTH 13th STREET
PHILADELPHIA



NOTE
THE
WOOD
WHEELS
EVERYWHERE

Compactness of Design

WHEN an engineer or designer is confronted with the problem of securing a certain gear ratio within a certain center distance, he many times experiences trouble in securing this ratio without sacrificing compactness of design.

The internal gear forms the most convenient method of attaining these results.

In many cases, also where a certain direction of motion is necessary, this can be secured by two instead of three gears, the two gears being the internal gear and the pinion.

The reason for this is that the pinion and the internal gear both run in the same direction, whereas two external gears run in opposite directions, and to get the same direction of motion, it is necessary to insert an idler or third gear. This not only greatly increases the center distance, but makes a compact design impossible.

Short compact center distances is one of the many advantages of the internal gear that is fully explained in our new book, "The Internal Gear—Design and Application" copies of which are now ready for distribution.

Kindly state name of firm and position occupied when requesting a copy of this booklet.

The Fellows Gear Shaper Company

Springfield, Vermont, U. S. A.

Foreign Agents: Alfred Herbert, Ltd., Coventry, England; Yokohoma, Japan; Calcutta, India; Société Anonyme Alfred Herbert, Paris, France and Spain; Societa Anonima Italiana Alfred Herbert, Milan, Italy.

Premier *Moon* *DENBY* *KISSELKAD* *PILOT* *Autocar* *Russel*
HAYNES *every inch a car* *HUDSON* *SUPER* *SIX* *Lippard* *Stewart*
8 *COLE* *STEPHENS* *SIX* *the Best* *for Truck in America*
REPUBLIC *BETHLEHEM* *Internal Gear Drive* *MOTOR TRUCKS* *SHELDON* *MARMON*
APPERSON *COLUMBIA AXLE* *KING "8"* *LEXINGTON*
EMPIRE *PIERCE* *ARROW* *TORBENSEN AXLE*
Auburn *Trundaar Tractor*
National

The choice of 51 leading engineers

Next to actual service, the best test of a brake lining is the company it keeps. We are quite content to have Thermoid Brake Lining judged by the quality of its friends.

Where Thermoid is used

Notice the varied types of cars in which Thermoid is used. High priced heavy cars where service—not cost—is the prime consideration. Lower priced popular cars whose makers are willing to pay a little extra for brake lining that gives the maximum safety. Thermoid is also used on the leading axles. The engineers designing these axles are particularly well qualified to weigh the merits of brake lining.

Why Thermoid was selected

There are three reasons why Thermoid has been selected by this critical body of competent judges.

1st—Over 40% more material and 60% more labor are used in Thermoid than in any woven brake lining. This gives longer wear.

2nd—Thermoid Brake Lining is Grapnalyzed, an exclusive process which resists moisture, oil and gasoline.

3rd—Thermoid is hydraulic compressed. It wears down slowly and can be used until it is cardboard thin.

If you are not specifying Thermoid we are confident that a personal investigation will confirm the judgment of these 51 engineers. Samples will be gladly sent.

Our Guarantee: Thermoid will make good—or WE WILL

Thermoid Rubber Company

Factory and Main Offices:

TRENTON, N. J.

Factory Branches:

New York Chicago San Francisco Detroit

Los Angeles Philadelphia Pittsburgh

Boston London Paris Turin

Canadian Distributors: The Canadian Fair-

banks-Morse Co., Limited, Montreal

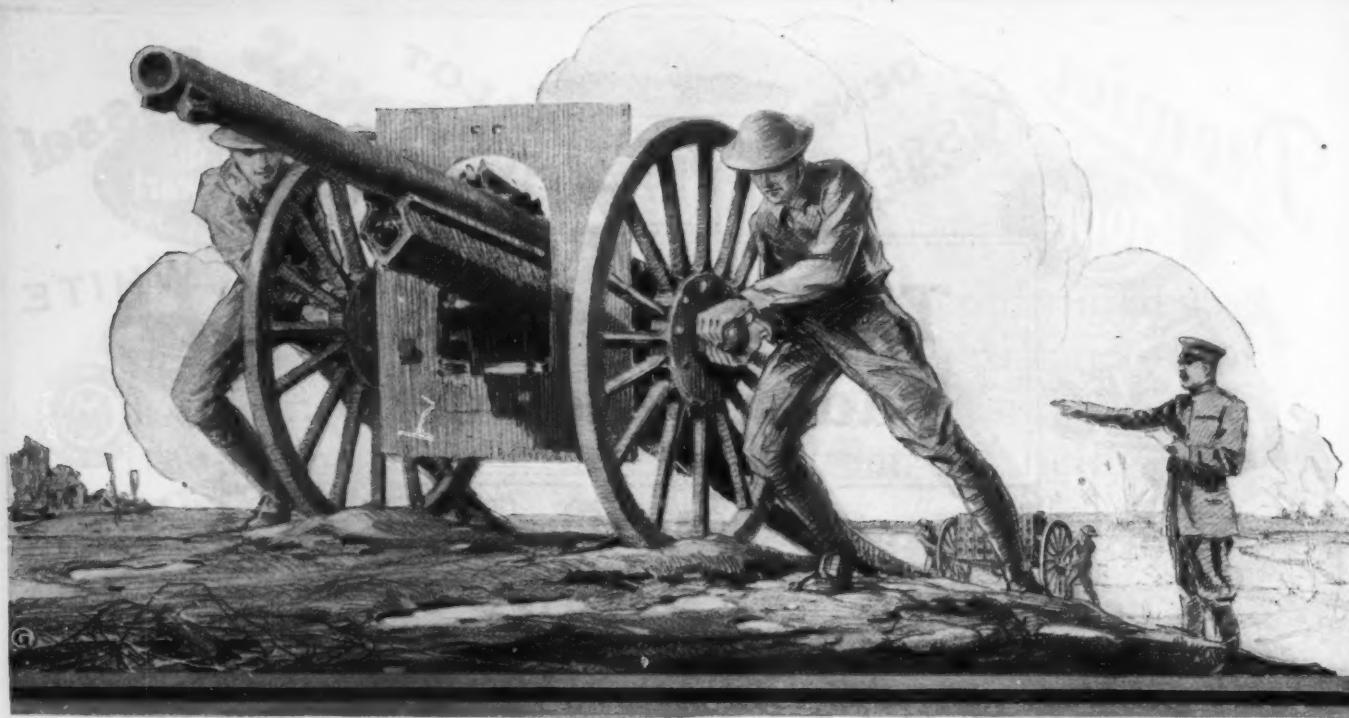
Branches in all principal Canadian cities

At speed of	A car should stop in
10 miles per hr.	9.2 ft.
15 " " "	20.8 "
20 " " "	37 "
25 " " "	58 "
30 " " "	83.3 "
35 " " "	104 "
40 " " "	148 "
50 " " "	231 "

Will your car do this?



Makers of "Thermoid Crolide Compound Casings" and "Thermoid-Hardy Universal Joints"



Turning a Wheel by the Hub is like Turning an Axle by Gear Drive

NO man would think of attempting to get a load out of the mud by turning the hub of the wheel with his hands.

He takes hold near the rim. It gives him leverage. It makes his energy and weight count.

This same principle applies to truck and tractor drives.

Chain drives bring the application of power nearer the rim of the wheel. They exert greater driving power.

That's one reason why the largest percentage of heavy trucks are chain driven. And that's one

reason why chain drives are being adopted as the final drive for tractors. Other reasons are greater economy in operation; ease of repair; longer ultimate life, etc.

Twenty-two makes of tractors employ Link-Belt Roller Chain. There are definite reasons for this large Link-Belt choice. Our Book No. 359 gives some of them. One of our engineers will gladly call and give you complete chain drive facts and reasons.

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181

LINK-BELT ROLLER CHAIN



Ward Leonard

Control Devices

For Dynamo, Motor and Storage Battery



Ward Leonard Electric Company
Mount Vernon, New York

Now engaged 100% in war work but ready, as soon as our
Country's needs are filled, to assist in solving your problems

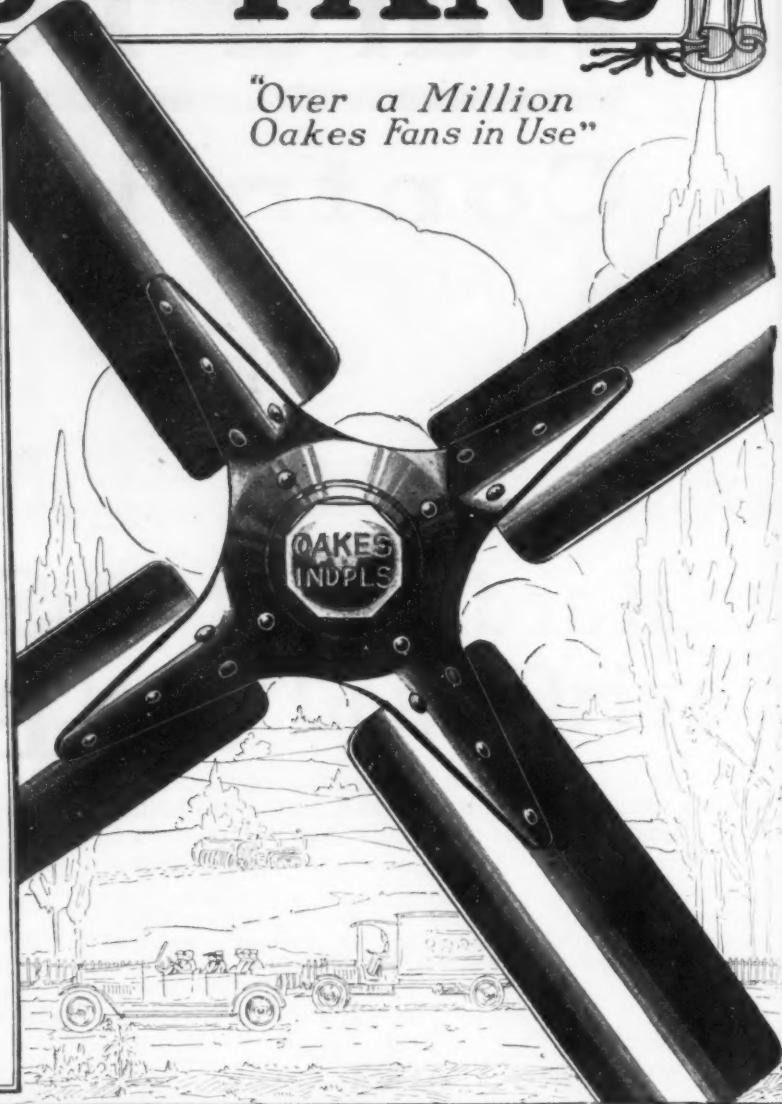
OAKES EFFICIENT COOLING FANS

Logical Choice of 230 Leading Tractor, Truck and Motor Car Makers

MORE than one million Oakes Radiator Cooling Fans are in use today as standard equipment on the big majority of American tractors, trucks and automobiles—230 makes in all.

Oakes Fans are the logical choice of these manufacturers because they give cooling service of highest efficiency with greatest economy of power. These manufacturers place permanent cooling efficiency and their customers' full satisfaction above first cost.

"Over a Million Oakes Fans in Use"



Oakes Big Advertising Messages

Such as this page, which is going to hundreds of thousands of buyers—carry the names of 230 leading makers who use Oakes Fans. Oakes represents real sales value on any truck, tractor or automobile because—

An Oakes Fan means a *good* fan in design, material and workmanship—and more. It means a close study by Oakes' engineers of every demand of service to which that particular fan will be subjected.

Back of every Oakes Fan stands the world's largest factory devoted exclusively to making radiator cool-

ing fans. The names of 230 makers who have chosen Oakes Fans for permanent cooling efficiency, present conclusive proof of Oakes superiority and predominance.

It will pay any maker to include Oakes Fans in his specifications.

Buyers insist on an Oakes Fan when they buy a tractor, truck or automobile. It is a guarantee of cooling service of utmost efficiency with the highest possible economy of power.

Office and Factory
Indianapolis
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THE OAKES COMPANY

Chicago Office
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Boulevard



HARRISON will be ready for the coming after-the-war automobile production. That includes not only facilities—2,000 radiators a day, made in the largest, most modern exclusively radiator plant in the country—but also the *quality* that will be demanded—

- strength with light weight
- big free air passages
- free flowing water circulation
- durability and simplicity
- all qualities which have built up the reputation of Harrison Radiators.

HARRISON RADIATOR CORPORATION
LOCKPORT, NEW YORK



FACTORS of SAFETY

*The Factor of Safety in Bridgebuilding is 4-5
The Factor of Safety in Pneumatic Tires is 10-14*

The bridge is immortalized in song and story. The very name suggests strength, carrying power, utility, safety.

The bridge flings a path over mighty rivers, crosses mountain divides, carries the shining steel rails for the flying wheels of commerce, east to west, north to south, scorning the obstructions of nature. It is a spear head in war for attack or defense.

If all the bridges were suddenly destroyed it would paralyze life and work at the most vulnerable point — transportation. And modern transportation depends largely upon the pneumatic tire.

Yet the Factor of Safety in Bridgebuilding is approximately but 4-5, as against 10-14 as the Factor of Safety in Pneumatic tires.

Is it not reasonable that the Hood Tire with its "extra ply" of fabric carcass possesses the greatest factor of safety you can buy in a tire? The Hood Tire is therefore the tire you should use upon your car to carry you with greatest immunity from tire mishap and to give you greater mileage in your service behind the front.

Look for this sign of the Hood Dealer

in your town or city. You will do well to call and see him — he is a good man to know.

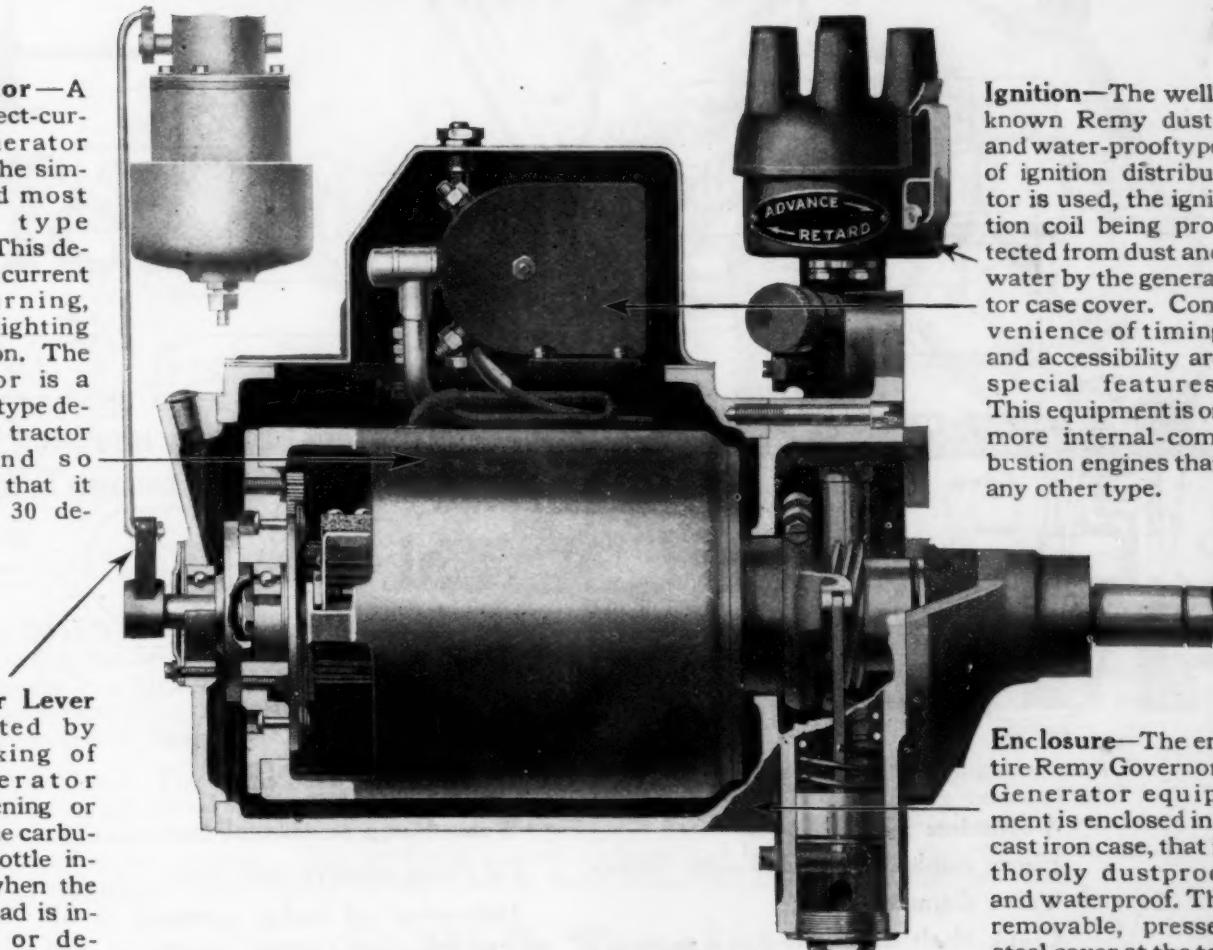
THE HOOD TIRE COMPANY, Inc.
WATERTOWN, MASS.



REMY

GOVERNOR-GENERATOR

Generator—A simple, direct-current Generator is used—the simplest and most efficient type known. This develops the current for governing, starting, lighting and ignition. The Generator is a standard type designed for tractor work and so mounted that it will rock 30 degrees.



Governor Lever—Operated by the rocking of the generator body, opening or closing the carburetor throttle instantly when the tractor load is increased or decreased, thus providing a perfect automatic, electric engine control.

The Remy Governor-Generator is the necessary key to the problem of electric engine governing, lighting, starting and ignition for farm tractors. This one device performs the duties of three units—a current generator, an engine governor and an ignition system. This elimination of multiple equipment makes for greater simplicity, greater durability and Remy constant performance.

REMY ELECTRIC COMPANY
TRACTOR EQUIPMENT DIVISION, CHICAGO, ILL.
Motor Equipment Division, Detroit, Mich. Factories, Anderson, Ind.

Ignition—The well-known Remy dust- and water-proof type of ignition distributor is used, the ignition coil being protected from dust and water by the generator case cover. Convenience of timing and accessibility are special features. This equipment is on more internal-combustion engines than any other type.

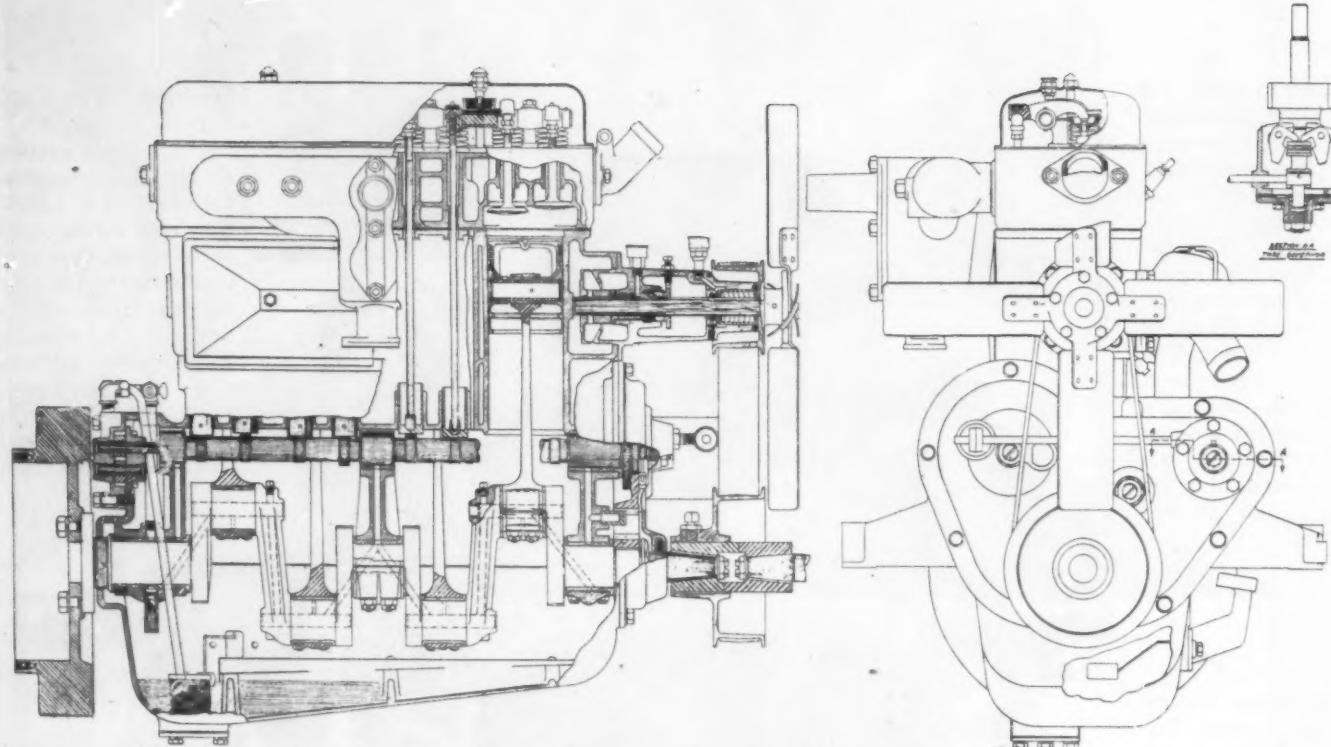
Enclosure—The entire Remy Governor-Generator equipment is enclosed in a cast iron case, that is thoroly dustproof and waterproof. The removable, pressed steel cover at the top permits easy access to all the parts thru a large inspection hole.



(Properly lighted it is as practical to follow a furrow at midnight as it is to drive the family car home after the band concert.)

WEIDELY

4-CYLINDER MOTORS FOR TRUCKS AND TRACTORS



MODEL "M" SPECIFICATIONS

4-cylinders $3\frac{3}{4}$ " x $5\frac{1}{2}$ ".

Piston displacement, 243 cubic inches.

Valve diameter, $1\frac{3}{4}$ ".

Crank Shaft diameter, $2\frac{1}{8}$ ".

Connecting Rod Bearing, 2 " x $2\frac{1}{4}$ ".

Water Pump centrifugal type.

Oil Pump positive feed type.

Delivering oil under pressure to all crank, cam, lower connecting rod bearings and timing gears.

Weidely valve in head motors are used with pronounced success by one of the largest builders of tractors. The performance of Weidely motors, under all conditions, is the only proof required of the care exercised in design, selection of material, workmanship, and specially designed tools, used in the construction of these motors.

WEIDELY MOTORS COMPANY
INDIANAPOLIS

What Does It Mean



In reading over the specifications of the leading tractors, you will see under Ignition the phrase "K-W High Tension Magneto with Impulse Starter."

The Impulse Starter

What Does It Mean? To manufacturers and owners of these tractors it means Sure and Easy Starting, regardless of how cold the weather, how large the motor or how slow the engine is cranked. It means No Batteries, No Starting Coils and No Complicated Self-Starters. It means absolute protection against motor "kick-backs" while cranking even when the spark lever is left fully advanced.

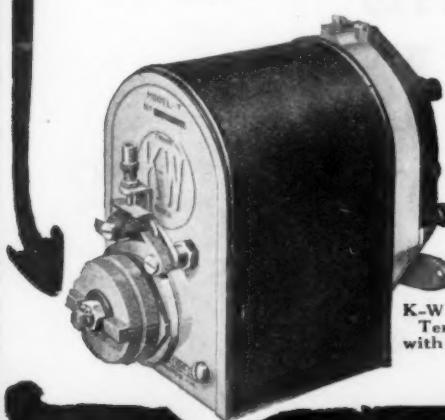
What It Does! The K-W Impulse Starter holds back the shaft or rotor of the magneto until the firing point of one of the cylinders is reached. The shaft is then automatically released and is propelled forward (by means of a powerful spring), at a very high rate of speed—until it catches up to its former position. This produces a spark as large and hot as though the engine was running at full speed, thus insuring an explosion in the cylinder and a positive immediate start.



not only insure the Easy and Quick Starting of cold motors, but increase the power derived from the same amount of fuel over that of any other ignition system. They permit the use of the cheaper grades of fuel and give "No Trouble" service.

The efficiency and reliability of K-W Magnetos has been proven by years of service. That is why forty tractor manufacturers are using them on eighty-three models as **Standard Equipment**.

Our Engineers will co-operate with yours. Write today for full particulars.



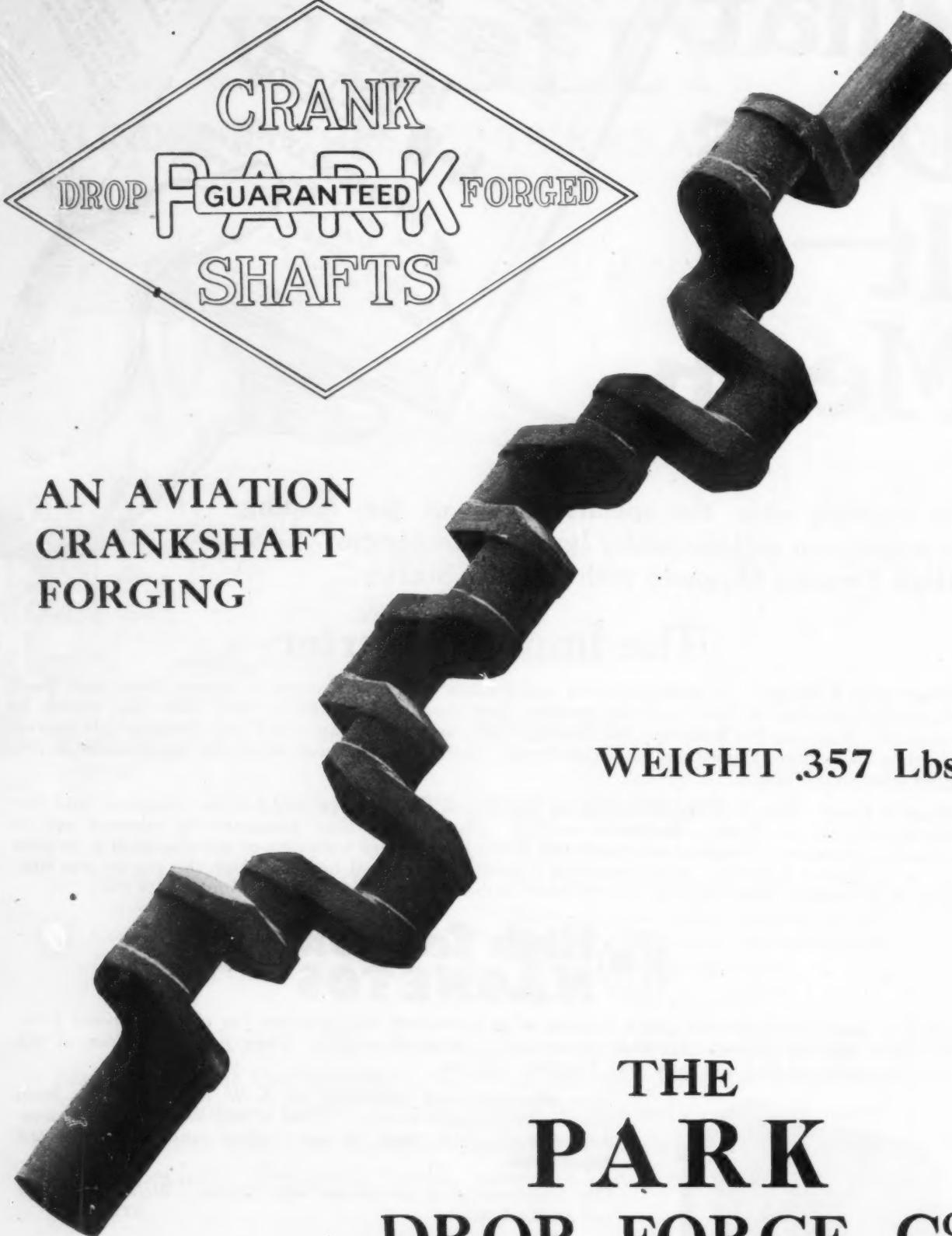
K-W Model TK High Tension Magneto with Impulse Starter

THE **K-W** IGNITION CO.
TRADE MARK
2843 Chester Ave. CLEVELAND, OHIO, U.S.A.



AN AVIATION
CRANKSHAFT
FORGING

WEIGHT .357 Lbs.



THE
PARK
DROP FORGE CO.
CLEVELAND, OHIO, U. S. A.

We Have Shipped 40,936 Aviation Crankshafts to November 16th, 1918

WASSON

Concentric Peened Piston Rings Of Uniform and Permanent Pressure

Patented and Protected by Wasson U. S. Patents
 1008999 Dated November 14, 1911
 1009000 Dated November 14, 1911
 1016380 Dated February 6, 1912
 Other Patents Pending

Some of Our Users

Aeroplane Makers

Packard, for Liberty Motor
 Wright Martin, Aircraft Corp.
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Automobile Manufacturers

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Nash	Marmon
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Chalmers	White
Peerless	Mitchell

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Wallace Tractor Co.
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WASSON PISTON RING CO., Plainfield, N. J.
LAKE SALES COMPANY, 1947 Broadway, N. Y. C.

SALES AGENT

Getting out the Timber with Motor Trucks

Our gigantic war preparations, which are a necessary forerunner of the victory we must win, have made heavier demands upon America's forests than ever before in history.

Here, as in many other industries, the biggest problem to be solved was the question of transportation—the hauling of the timber from the forests to the mills and the delivery of the lumber from the mills to the place of its ultimate use.

In this emergency, the lumber industry turned to motor trucks as its only salvation, and the trucks have been and are doing a noble service in bringing out the logs from the forest camps and in delivering the lumber to airplane factories, to army camps, to shipyards,—wherever it is needed.

In their use as standard steering equipment on 115 different motor trucks, representing considerably over half the industry, Ross Gears have earned the distinction of being

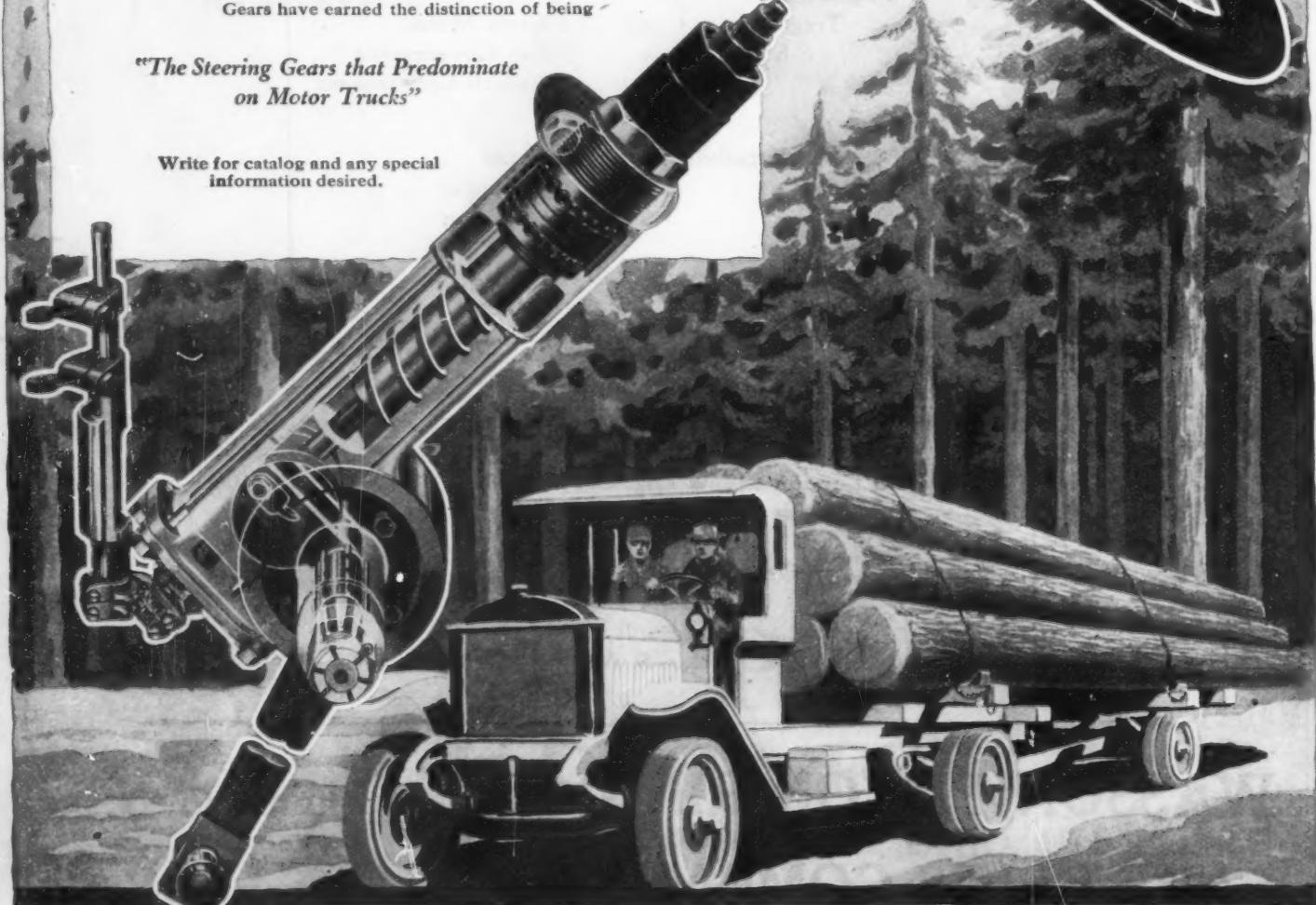
*"The Steering Gears that Predominate
on Motor Trucks"*

Write for catalog and any special information desired.

Lumber men have found that in their every-day business, motor trucks enable them to make longer hauls of heavier loads, to render more efficient and more reliable service, and to reduce their delivery costs. They know also from recent experience the value of the greater speed and the larger carrying capacity in a National emergency.

Everyone appreciates that sturdy construction is essential in every detail of a motor truck used in the lumber business or in any other heavy service, but without investigation, the average person does not realize the vital importance of the steering gear.

Those who appreciate the value of enormous bearing surfaces in guaranteeing safety, reliability and easy steering, will demand Ross Steering Gears in the trucks they buy.



Ross GEAR & TOOL COMPANY, Eighth & Heath Sts., Lafayette, Ind.

You Can't Put Your Gear or Differential Work Into Better Hands

Here is why

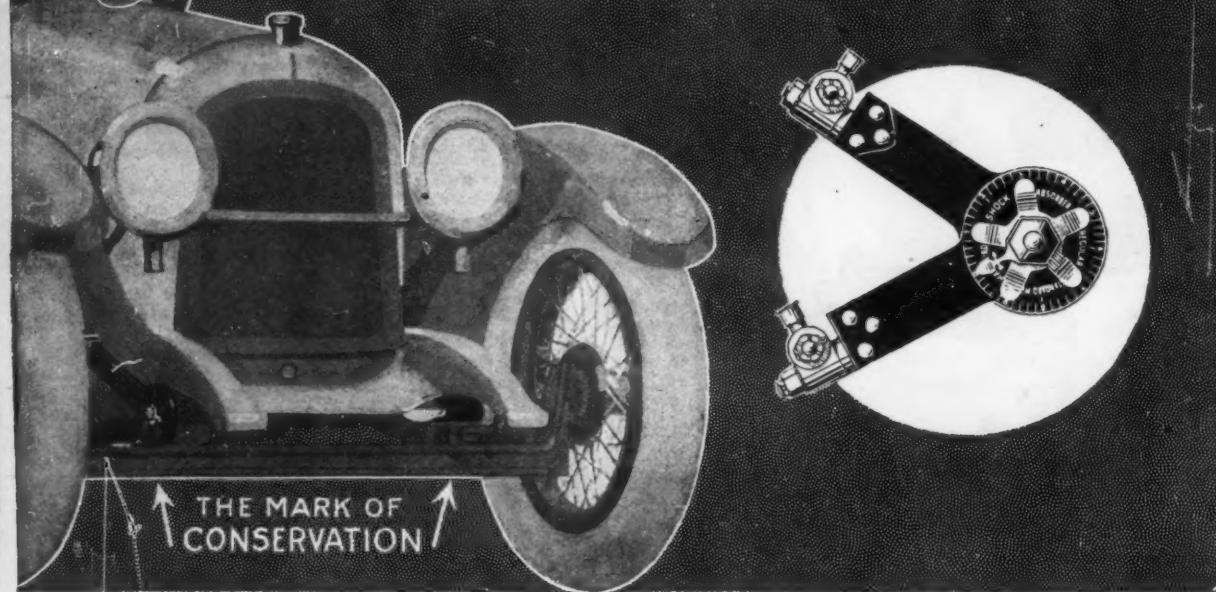


1. Twenty-nine years of making gears exclusively gives us the "know-how."
2. Our plant is the world's largest devoted exclusively to gear-cutting.
3. Our equipment includes every desirable tool for quantity production, for precision and for uniformity of machining.
4. First class work is further assured by the continued use of thousands of our gears usually as standard on leading makes of machine tools and automobiles.
5. Prompt delivery is assured by our large capacity (Bevel gears alone 3500 per day) and by our large stock of metal and patterns.
6. Attractive prices because every job goes onto the most economical machine and is handled by men long experienced in that particular line.
7. Complete or partial service as desired, including pattern work, furnishing brass, bronze, iron or steel castings, forgings of bar stock, blanks, cuttings, carbonizing, hardening or finishing complete.

We manufacture gears and differentials for all automobile, truck and tractor needs. Send us specifications for prices.

 **NEW PROCESS**
GEAR CORPORATION
SYRACUSE, N.Y.

You'll see it on the Best Cars



Is the Judgment of Your Contemporaries
Worth Anything to You?

Scan this list of cars factory-equipped with the

Hartford
SWIVEL TYPE
SHOCK ABSORBER
MAKES EVERY ROAD A BOULEVARD

and mark well the fact that here are the names of most of America's representative makes:

Apperson
Biddle
Cole
Crawford
Daniels

F. R. P.
Haynes
Marmon
McFarlan

Mercer
Murray
National
Owen-Magnetic

Pierce-Arrow
Revere
Singer
Stutz

Such authoritative endorsement puts this pioneer shock absorber in the essential class.

Factory and road tests preceded the adoption of the Hartford as standard equipment on these, the majority of the country's finest cars. Such tests afford the best evidence of the Hartford's indispensability.

We invite you to test Hartford Shock Absorbers on your car with the co-operation of our engineers.

EDWARD V. HARTFORD, Inc.
240 MORGAN ST., JERSEY CITY, N. J.

Branches: NEW YORK, BOSTON, CHICAGO, KANSAS CITY. Distributors in Principal Cities.

SCREW MACHINE PARTS
DO YOU REQUIRE CLOSE TOLERANCES
AND CAREFUL MACHINE PRACTICE?

Our plant is accustomed to making screw machine parts under the very rigid requirements called for in the Aircraft Industry, parts whose interior structure must be identifiable—quality the determining factor.

Will you take advantage of the facilities of a fully equipped screw machine plant, new modern automatic machines—complete machine shop, laboratories, cyanide case hardening equipment and two electric heat treating furnaces?

Let us quote you on your screw machine parts. Favor us with your blue prints, specifications, etc.

ERIE SPECIALTY CO.
8 West 40th St., New York City
Main Plant Erie, Pa.

**QUALITY
SNAP RINGS**

Play a Prominent Part in
America's Gas Engine Construction

The Piston Ring Company
SPECIALISTS IN PISTON RINGS
108 SANFORD ST. MUSKEGON, MICH.

Positions & Men Available

The following announcements are published for the information of members of the Society. No charge whatever is made for these. Additional information will be supplied by the office of the Society. When items are prefixed by asterisk, written applications should be sent to S. A. E. office to be forwarded. Applications from non-members for positions must be properly endorsed by a member of the Society.

POSITIONS AVAILABLE

DRAFTSMEN who are good on checking are wanted for Government aircraft work. Men available as draftsmen should communicate with the office of the Society, located in the Munsey Building, Washington. They will be put into communication with Government personnel officers in various branches of the services.

COMBUSTION ENGINEER The Bureau of Oil Conservation, Oil Division, U. S. Fuel Administration, desires a combustion engineer for each of the following districts, who will act as an inspector, visiting all plants within his district using fuel oil and natural gas: Pittsburgh, Buffalo, Detroit, Minneapolis. Volunteers desired, but the Administration is prepared to pay a reasonable compensation for men who cannot afford to give their services to the Government. Only men who have had experience in fuel oil and natural gas combustion would be of value. Apply, Oil Division, United States Fuel Administration, Washington, D. C.

DRAFTSMEN are urgently needed in the Bureau of Construction and Repair, Aeronautic Division, Navy Department. Apply as above to Lieut. Dickerson, personnel officer of this department, Eighteenth and B streets, Washington, D. C.

TECHNICALLY TRAINED PERSONS are needed for the examining corps of the Patent Office. Men or women are desired who have a scientific education, particularly in higher mathematics, chemistry, physics and French or German, and who are not subject to the draft for military service. Engineering or teaching experience in addition to the above is valued. The entrance salary is \$1,500. Examinations for the position of assistant examiner are held frequently by the Civil Service Commission at many points in the United States. Details of the examination, places of holding same, etc., may be had upon application to the Civil Service Commission, Washington, D. C., or to U. S. Patent Office, Department of Interior, Washington, D. C.

519 **MECHANICAL DRAFTSMAN**, with about one year's experience in automobile work preferred. Shop experience desirable but not necessary. Give complete details as to experience and salary expected in first letter. Location, Indiana.

525 **METALLURGIST** Excellent position in one of the largest aluminum foundries of the East. Must be in good standing, and experienced in handling aluminum from both the material and foundry point of view. Excellent opportunity for the right man. Location, New Jersey.

536a **MECHANICAL DRAFTSMAN**, preferably with experience in motor-vehicle work. State age, experience, and salary required. Excellent opportunity.

(Continued on page 52)



ON the belt pulley Hyatt Bearings withstand the combined effects of high speed and the heavy load due to belt tension.

And in the drive wheels Hyatts carry the greatly increased load caused by gear tooth pressure, the weight of the tractor and the draw-bar pull.

But, be it belt pulley or drive wheel, front axle or fan shaft, it is possible to secure a Hyatt Bearing that has proved—thru years of actual farm tractor service—its superior fitness for any given condition of application.

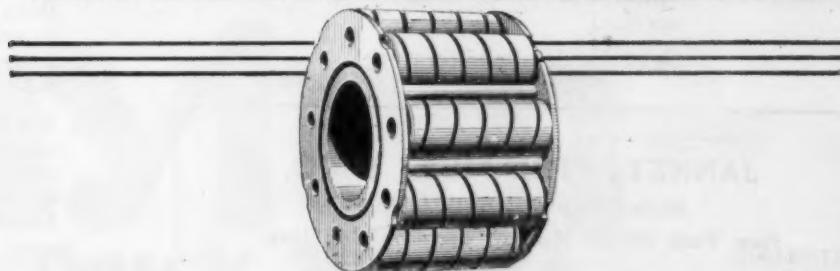
This wide range of usage is made possible by the ability to vary the construction of the spiral, flexible roller that distinguishes the Hyatt Bearing from all other types and makes.

HYATT ROLLER BEARING COMPANY
TRACTOR BEARINGS DIVISION, CHICAGO, ILL.

Motor Bearings Division
Detroit, Mich.

Industrial Bearings Division
New York City

HYATT ROLLER BEARINGS



"A Sure Start Assured"

means that the car
is equipped with

An "Exide" Battery

the battery that
"costs most to make
but least to use."

**THERE'S AN "Exide"
BATTERY FOR
EVERY CAR**

THE ELECTRIC STORAGE BATTERY CO.

1888 PHILADELPHIA, PA. 1918 -

New York, Boston, Washington, Minneapolis, Denver,
Detroit, San Francisco, Kansas City, Chicago, Cleve-
land, Atlanta, Pittsburgh, St. Louis,
Rochester, Toronto



USED ON HIGH-CLASS MOTOR VEHICLES

as the one absolutely satisfactory gasoline carrying receptacle.

Only the finest steel is used in making "Jasco" tanks. They are seamless drawn, tinned and tested—will not leak under the severest strain of the roughest service.

Send for detailed literature.

JANNEY, STEINMETZ & CO.

Main Office: PHILADELPHIA

New York Office: Hudson Terminal Building

POSITIONS & MEN AVAILABLE *Cont.*

Positions Available (Continued)

536b **MATHEMATICIAN** Young man, capable of handling engineering calculations with accuracy and despatch.

State age, experience, and salary required. Excellent opportunity.

537 **CHEMIST** for iron foundry. Practical experience in actual operation of cupolas and furnaces, and a theoretical knowledge of the chemical constituents of iron mixtures desired. Location, Western Pennsylvania.

*543 **TRUCK BODY ENGINEER** desired by growing company. References consulted only on explicit permission. Excellent opportunity. Location, one hour's ride from New York City.

546 **PRODUCTION ENGINEER** A well-known motor truck manufacturer desires to get in touch with a thoroughly experienced motor truck production engineer. An excellent proposition in the way of salary and bonus will be offered a man who has already demonstrated his ability in some successful motor truck organization.

547 **DESIGNERS** with experience in automobile work, for motor truck design. Location, New York City.

553 **RUBBER EXPERIMENTAL ENGINEER**, qualified to carry on the experimental and development work on all types of rubber tires, needed by large rubber company. Must be painstaking and thorough and have original ideas. Man with technical training and rubber experience preferred. Replies will be considered strictly confidential. Application should give complete statement of experience and qualifications. Location, Ohio.

554b **METALLURGICAL FOREMAN** Experienced man wanted for heat treating department in connection with alloy steel for automobile and airplane engines. Permanent position for the right man. State age, experience, education and salary expected. Location, Western New York.

558 **EXPERIMENTAL ENGINEER**, with experience on heavy trucks. One who can deduce correct conclusions from observed phenomena and make practical, common-sense recommendations to the chief engineer. Location, near New York City.

*560 **DRAFTSMAN** and **DESIGNER** who has had experience in internal-combustion engineering, including research and development. Those answering please state full experience, age and last position. Location, Brooklyn, N. Y.

561 **FACTORY MANAGER** or **FACTORY SUPERINTENDENT**, for plant manufacturing plain, formed, drawn and deep-drawn stampings, also automatic screw machine products. Must be able to estimate on these classes of work, estimate cost of dies and tools, design the necessary dies and tools, be able to produce, and to organize those under him. Will make satisfactory compensation to any man who can prove his ability to handle the proposition. Prefer a man now engaged in similar business.

*562 **METALLURGIST** Must be technical graduate and experienced in the metallurgy and heat treatment of alloy steel, preferably man who has had experience in the automotive or allied industry. Excellent opportunity. Location, East.

(Continued on page 54)



A Wheel that adds to Truck Capacity

The rating of every motor truck is often tested to the extreme limit. A rated capacity of three tons does not prevent the user from adding an extra thousand pounds every now and then.

For this reason makers are constantly striving to increase the carrying capacity of their trucks. They realize that every bit of added strength will help their trucks stand up under the extra pressure of overloading.

The Dayton Steel Wheel gives a motor truck that much needed super-strength. Because it is cast in one integral piece, there are no spokes to become loose under the strains of rough roads and heavy loads. Constant overloading cannot weaken it.

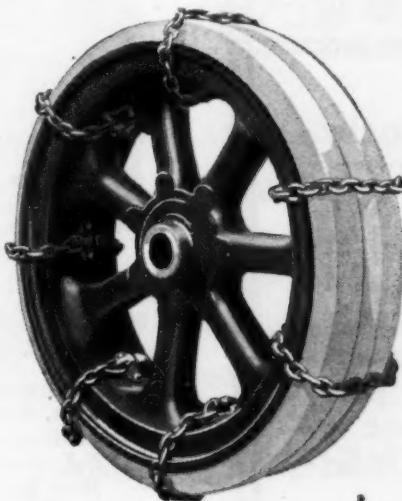
The broad, sweeping curves and hollow spoke and rim construction of the Dayton Steel Wheel give a resil-

iency which dissipates road shocks, and thus prevents the full force of such shocks from reaching bearings, axles, motor or other vital parts. This allows those important parts to do their full duty at all times.

The hollow spoke and rim construction also gives lightness, without sacrificing strength. In most instances the Dayton Steel Wheel is lighter than any types of built-up wheels. And every pound you save in wheel weight means ten pounds gained in truck-carrying capacity.

From this standpoint alone the Dayton Steel Wheel will interest you.

Now that the war is won, our entire output will again be at the disposal of commercial truck makers. We can now furnish sample sets if you are not already familiar with the qualities of the Dayton Steel



Wheel. Let us send you our folder, "The Final Motor Truck Wheel and Why."

The Dayton Steel Foundry Co., Main Office and Works: Dayton, O.

Detroit

Chicago

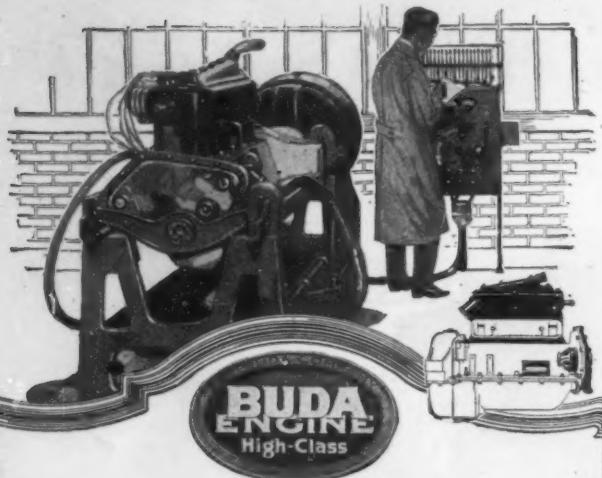
Cincinnati

New York

===== **Dayton** =====

Steel Truck Wheels

PATENTED



Five Times Tested - and Proved!

The smoothness in action and remarkable durability of the BUDA ENGINE are the results of the finest manufacture. They are safeguarded by tests of each engine which, we believe, are of unequalled severity.

1st, each engine is run by outside power until smooth. 2nd, it is run by its own power until smooth. 3rd, it is taken apart, examined and carefully adjusted. 4th, it is run under its own power. 5th, when it runs with perfection, its power output is measured by the electric dynamometer.

The engines which survive all these tests are real BUDA ENGINES for trucks, farm tractors, or high duty stationary work.

Made by The BUDA COMPANY, Harvey (Chicago Suburb), Illinois.

THE BUDA ENGINE
"HIGH CLASS"

POSITIONS & MEN AVAILABLE *Cont.*

Positions Available (Continued)

563 **SALES ENGINEER** Man under 35, with good appearance, engaging personality and selling ability. College education along electrical lines. Technical and practical knowledge of telephone equipment and of electrical apparatus, installation and equipment in general. Some knowledge of ship building would be useful. Drawing account, traveling expenses paid and commission. Location, Pacific Coast.

564 **ELECTRICAL ENGINEER** High-grade man to understudy chief engineer of large plant. Must be thoroughly grounded in fundamentals of electricity, able to perform electric calculations of any desired complexity. With practical experience in the quantity manufacture of small apparatus. Conversant with modern shop methods. Location, Indiana.

566 **LAYOUT MAN**, first class experience on automobiles or truck design.

567 **DESIGN AND LAYOUT MAN** Should have good general knowledge of electrical construction with sufficient practical or technical training to be able to lay out a well-balanced design, together with a knowledge of quantity production. Required for the mechanical design of lighting, starting and ignition equipment for internal combustion engines.

*568 **CHIEF DRAFTSMAN** required in an aeronautical industry. Must be a man with initiative and live in or near New York City. Salary \$4,000 to \$5,000.

*569 **CHECKERS** required in an aeronautical industry. Must be high class men with at least four years of checking experience, one year of shop experience and two on the drafting board. Salary \$1,800 to \$2,400.

578 **SKILLED DRAFTSMAN** for automotive and other work.

*579 **DRAFTSMAN**, experienced in tracing and detailing. Excellent opportunity with expanding truck concern in the vicinity of New York City.

580 **ENGINEER** thoroughly experienced, familiar with farm tractor designing and engineering.

*581 **AN AMERICAN**, between 30 and 45 years of age, with at least five years' experience as buyer in the metal products trade, two years in buying materials used in the construction of electrical generators and motors. Must have good health, attractive personality, good sound understanding of general basic business principles and be progressive, with initiative and moral courage. Location, Middle West. Name salary desired.

*582 **CHIEF INSPECTOR** middle-aged, resourceful and systematic, with organizing and executive ability. Essentials: Thorough training, with considerable practical experience in the manufacture of small electrical devices; knowledge of insulating materials and the intricate processes incident to building wire-wound insulated apparatus; familiarity with machine-shop practice, operation, testing and inspection. Name salary. Location, Indiana.

*583 **ENGINEER**, 28 to 35 years of age, with selling experience or salesman with engineering knowledge. Desirable to know ball-bearing field. Must be keen and aggressive, yet tactful and popular, willing to build from foundation up on sound engineering principles. Salary \$3,000 to \$4,000. Location, Chicago.

(Continued on page 56)



Peel off layers to required thickness

Why waste valuable time *fitting* solid shims? Why waste labor *assembling* loose-leaf shims? Both operations cost money and diminish profits. LAMINATED Shims are made as easily as lifting paper from a pad. In these thrifty times—everyone turns toward—

LAMINUM

LAMINATED Shims have been adopted by leading Governments, manufacturers, engineers, dealers, jobbers, repairmen throughout the world, because LAMINUM gives *better* results and saves time, labor and money.

LAMINATED SHIM COMPANY
533 Canal St. New York City

DETROIT: Dime Bank Bldg. ST. LOUIS: Mazura Mfg. Co.
ENGLAND: R. A. Rothernel, 6 Great Marlboro St., London, W.

Absolutely accurate surface like glass



BALANCING MOLINE TRACTOR CRANKSHAFTS

Even in a husky product like a farm tractor vibration is a very important item, and manufacturers of the highest grades take great care to secure as near accurate balance of their crankshafts as possible.

To get static balance on level ways is a comparatively simple matter, but to find the running unbalance of a long cumbersome crankshaft and correct it exactly, has previously been one of the most bothersome problems to both mechanics and engineers.

The above illustration shows how the Moline Plow Works have solved this in their tractor plant with a

CARWEN

Dynamic Balancing Machine
(ANIMOP PATENTS)

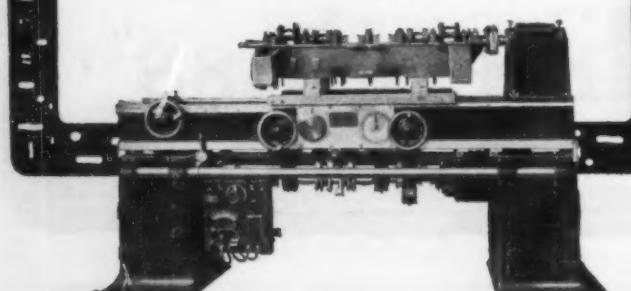
With ordinary shop skill, it is now possible to accurately locate where and measure exactly how much metal should be added to (or removed from) a crankshaft to put it in precise running balance.

Carwens are being successfully used by the largest electrical concerns for balancing armatures and turbine rotors; by the leading gas engine manufacturers for airplane, passenger car and truck crankshafts and the cost of purchasing and operating in all cases is practically negligible as compared with the gain in output and increased efficiency of the product.

Made in sizes suitable for balancing objects weighing up to 15,000 lbs. Write for our illustrated catalog.

Carlson Wenstrom Co.

Erie Avenue at Richmond Street
Philadelphia, Pa.



POSITIONS & MEN AVAILABLE *Cont.*

Positions Available (Concluded)

*585 An established firm in Chicago requires a mechanical, technical graduate, experienced in metal foundry work for bearings and in machining and finishing bearings to exact sizes. Some chemical knowledge desirable. Responsible position, requiring ability to handle men and to plan, supervise and direct the work and develop quantity production of a standard article. State age, whether married or single, education, previous experience and salary expected. Give references.

*586 LAYOUT DRAFTSMAN must be familiar with designing of transmission and axles for heavy, passenger vehicles, and a good checker. Permanent position with opportunities. Salary \$175 a month. Applicant must give details.

587 GOOD LAYOUT DRAFTSMAN familiar with internal gear drive.

588 LAYOUT DRAFTSMAN familiar with engine design for motor trucks.

589 CHASSIS layout draftsman for motor truck company.

MEN AVAILABLE

0528 ENGINEER experienced in the design and production of automobiles, airplanes and firearms.

0529 ENGINEER—Designing or production Practical experience covering designing, production, inspection and experimentation for the past eight years. Not a college graduate. Good organizer; able to handle men; capable of developing original ideas through designing, experimental and manufacturing phases. Aggressive clean-cut personality; age 35; married. At present in charge of engineering department covering designing, experimentation, inspection and pattern making. Interested particularly in truck engineering. Available Dec. 1.

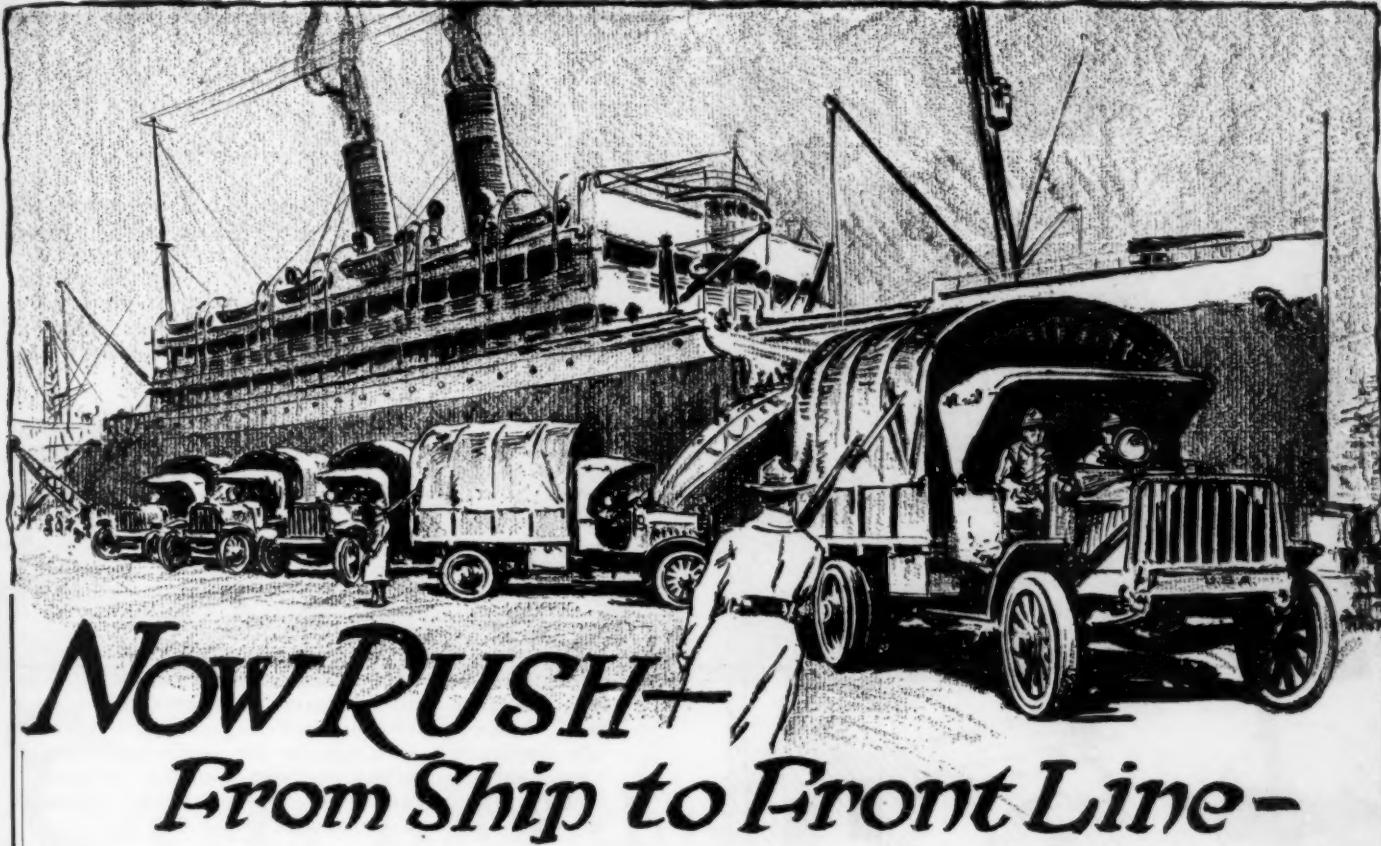
0530 EXPERIMENTAL ENGINEER Two years' laboratory experience in lighting, starting and ignition; ten years' shop practice and three years' executive; at present manager of a service station company; is expert on gasoline engine maintenance; has technical training; is ambitious and has initiative. Wants position where performance counts for promotion. Draft exempt, 29 years of age.

0533 ENGINEER Nineteen years' experience in operation, design and production of commercial and industrial trucks. Engineer for the past five years of one of the oldest truck companies in the East. Available immediately.

0534 GRADUATE ENGINEER, possessing high executive ability and having fifteen years' experience in designing, experimental and inspection work on all classes of passenger and commercial cars and their component parts, will shortly be free to take a position with a firm now doing war work, and also planning after-war work.

0535 TECHNICAL EXECUTIVE with broad American and foreign experience desires position abroad, preferably in reconstruction work in France or England. American born, college graduate, S. A. E. member, age 31, Class IV. Experienced as engineer and executive in production, design, tool work, organization and management. Well balanced, resourceful, dependable. Salary \$8,000 to \$10,000.

(Concluded on page 58)



Now Rush— From Ship to Front Line—

Not a lost minute—no breakdowns tolerated—a man-sized job for a truck with the real stuff in it.

For a reasonable life at this strenuous work a truck must have a transmission designed right and built to withstand the most unusually severe shocks continuously. Such are

BROWN-LIPE TRANSMISSIONS

Particulars will be furnished to owners, dealers and manufacturers on request.

BROWN-LIPE GEAR CO. TRANSMISSIONS

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Representatives:

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Model 60-4-
Speed Trans-
mission for 4
to 7 ton trucks

Every man who does his best whether as fighter or worker is a Patriot. Work full time, stick to your job.

Secretary of Labor.

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ELECTRIC
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ROCHESTER, N. Y.
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Manufacturers of
ELECTRIC STARTING,
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APPARATUS FOR
AUTOMOTIVE VEHICLES

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(United Motor Industries, Ltd.)

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may be guaranteed by using

KINSLER - BENNETT

TWO-JOINT PROPELLER-SHAFT ASSEMBLIES

Sizes For

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The quality of K-B products is of the best special drop forge steel throughout. Our interests are your interests. We will gladly help you plan your layouts.

THE KINSLER-BENNETT CO., Inc.
254 Market Street, HARTFORD, CONN.

The American Distributing Co.
Direct Factory Representatives
Kresge Bldg. Detroit, Mich.

POSITIONS & MEN AVAILABLE Cont.

Men Available (Concluded)

*0536 FIFTEEN YEARS technical and practical experience, six years as executive. At present with one of the largest automobile parts companies. Wishes to get in touch with financial business man or promotor looking for man of ability to organize new business or give new life to old one. Experience covers all branches of manufacturing. Considered diplomatic; have pleasing personality.

*0537 ENGINEER who has specialized in design of electrical equipment wishes position as assistant engineer with a firm manufacturing passenger cars, engines or electrical equipment for these.

*0538 ENGINEER with experience in parts designing and automobile building. Carburetor expert. Factory manager for several years. Experience in well-known factories. Salary \$3,600. Available at once.

*0539 ELECTRO-MECHANICAL ENGINEER, 34 years of age, college graduate with 12 years' experience in research work, designing and manufacturing of electric automobile appliances, is available for executive position. Thoroughly trained for precision, quantity production, factory management and efficiency work. Intimate knowledge of the automobile trade.

*0540 MECHANICAL ENGINEER Nine years' experience as chief engineer, six years with a company manufacturing farm tractors and implements. At present in the Motor and Vehicle Division on truck production. Graduate Cornell University in electrical engineering. Age 33, married. Available in 30 days.

*0541 AMERICAN ENGINEER, fine practical experience in important manufacturing firm, wishes position as designing and experimental engineer or as service manager in passenger car concern. Graduate of University of Michigan. Salary \$2,500. Available immediately.

*0542 AUTOMOTIVE ENGINEER 24 years' experience in development and refinement of internal combustion engine and other power producing and transmitting mechanisms. Practical organization and executive experience. Lately concentrating on motor fuel economy and able to apply the automotive lessons of the war.

*0543 GAS TRACTOR ENGINEER Member. Nine years of practical tractor experience and five years in various other lines of engineering. Thoroughly conversant with automotive engineering and development. Executive ability. Well poised, yet aggressive. Has always obtained results.

*0544 GRADUATE MECHANICAL ENGINEER, twenty-four years old single, desires position as assistant to superintendent in a tractor or engine company. Good references. Location immaterial. Salary expected \$2,500, if position is in this country.

*0545 SPECIALIST IN MARINE OIL AND GAS ENGINE DESIGN Seventeen years practical experience in development and research work; extensive training in fine points of technical and business side of combustion engineering. Competent to handle men and perfect engine designs. Excellent man for assisting war plants that contemplate shifting their output into new lines. Salary, \$4,800.



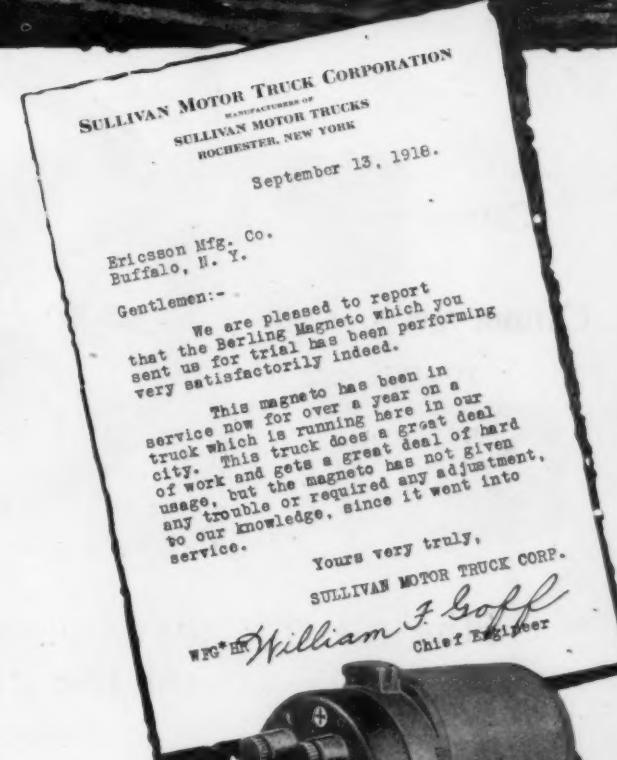
Tests like this have built Berling success

It is the automotive engineers of America, in their tireless search for perfection in their product, who have built the Berling's wonderful success.

One by one, the leaders in every automotive industry have made their tests—then adopted the Berling. Because the Berling best fulfilled their ideal of magneto performance.

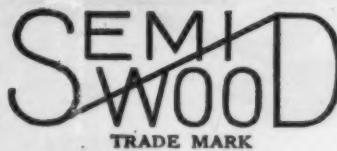
One hundred thousand Berlings now in use, are mute testimony to the sound judgment of these engineers.

ERICSSON MFG. CO.
Buffalo, N. Y.



Berling Magneto

WORTH MORE DOES MORE



SEMI-WOOD WHEELS

50% Stronger

Lighter Overall

Less Peripheral Weight



Cannot warp

Cannot get out of round



All the supports for demountable rim are directly over the ends of the wood spokes

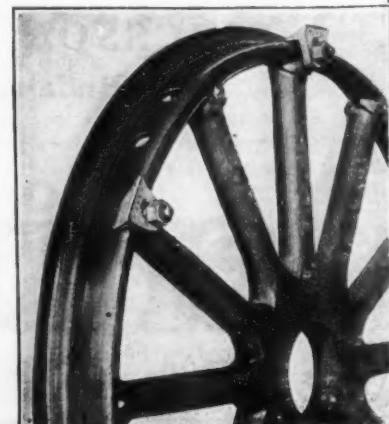
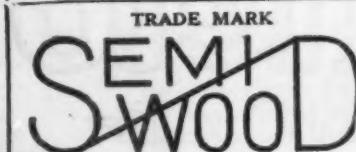
Has all the advantages of other wheels and none of the disadvantages

Now in production in all Government Standard sizes

BAKER WHEEL & RIM CO.

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**WHERE
PERFECT
CONTROL
is
VITAL**



Taking for our example Fifth Avenue, New York, where the automobiles are shown more plentifully than perhaps on any other avenue in the country, we are graphically illustrating how essential perfect control is. For there should be no delays, no congestion of any kind, but at all times maximum efficiency.

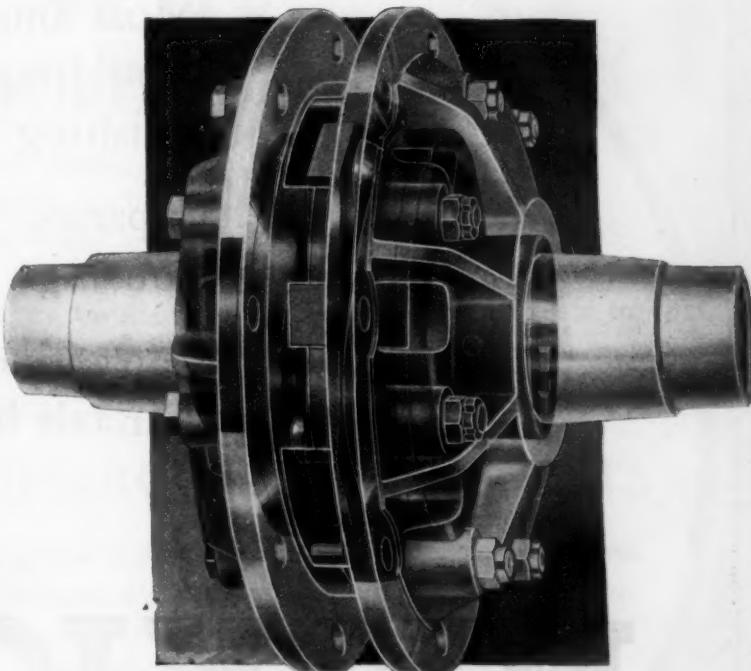
Every automobile engineer is aware of the control inefficiencies of the gear type of differential.

In the Dorr Miller Differential, those inefficiencies have been entirely eliminated. It accomplishes what the conventional type of differential fails to do—the transmission of uniform driving power to both wheels alike, irrespective of the traction surface of either wheel.

The Dorr Miller Differential eliminates wheel spinning—reduces skidding and ensures positive differential action.

It will pay you to investigate this simple, positive and practically wear proof differential, which is applicable to any type of automobile without change in axle housing.

Test on a Fifth Avenue Coach has been going on for several months and proves the validity of our claims: Perfect control where perfect control is vital—Fifth Avenue, New York—and absolutely eliminating congestion or delays due to skidding or spinning has been overcome by the Dorr Miller Differential.



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HOUSINGS our specialty.

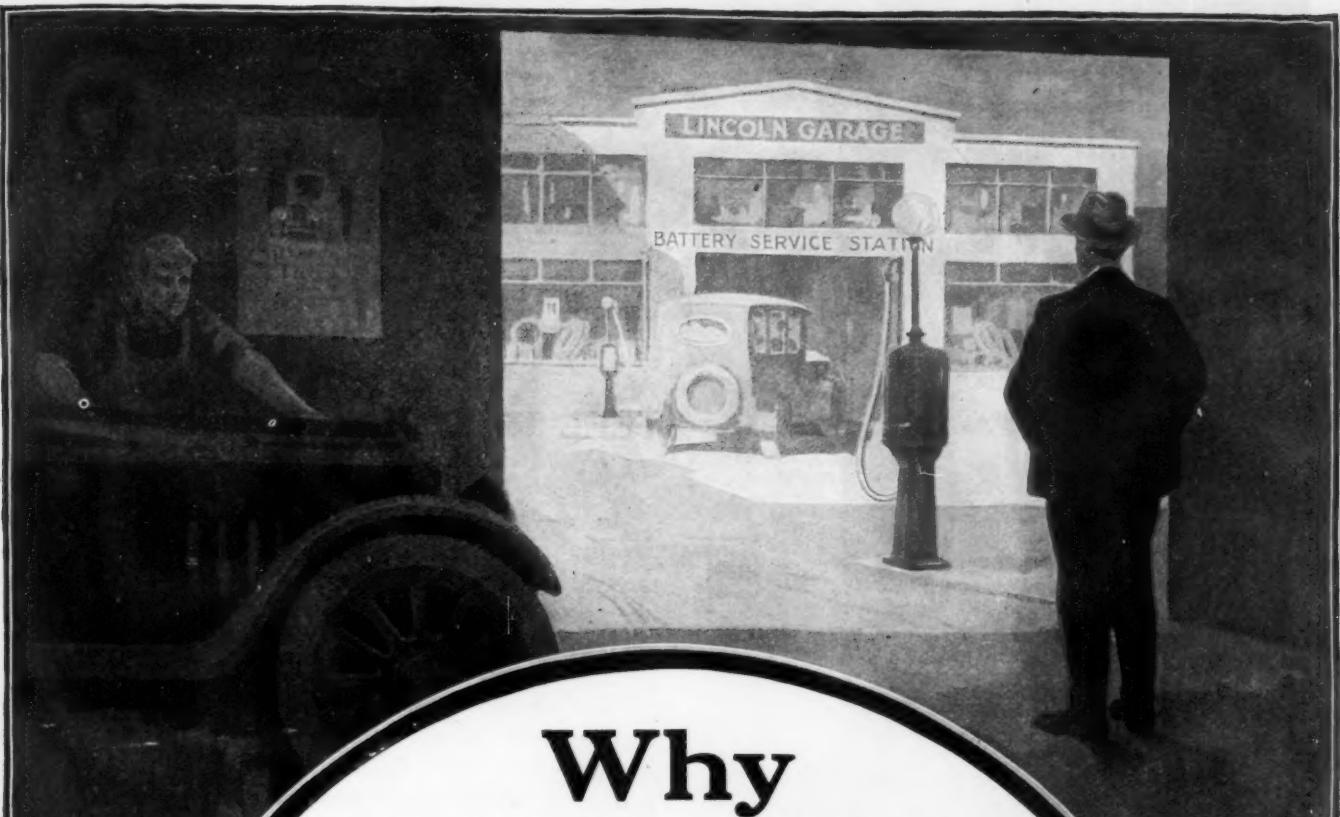
Most improved machine-moulding, annealing and finishing equipment.

Separate department for housings.

Capacity one hundred full rear axle housings per day.

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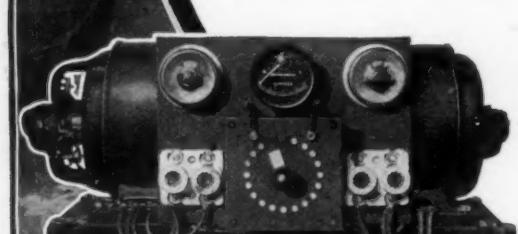
Without a Battery Charging Outfit, the direct profit from this source is lost. Indirectly, much other business also is lost; because motorists demand *complete* service and dislike the inconvenience of scattering their patronage. You bait your competitor's hook when you force a customer to go elsewhere for what *you* should supply him; he is apt to transfer all his patronage to the other fellow. Numbers of

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BATTERY CHARGING EQUIPMENTS**

throughout the country are daily proving their worth as business builders. Their ruggedness and economy of operation are assured by Westinghouse manufacture, and they represent a most effectual means of making your garage service complete. Write for folder number 4313-B.

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In no line of manufacture is the value of experience more clearly demonstrated than in the manufacture of alloy steels.

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We have been making alloy steels for over a decade.

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Especially Adapted for

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Line Reaming Bearings of Motor Generator Sets and Turbines.

Accurately sizes each bearing in true alignment.

Reaming all the main Bearings of a six cylinder engine case in alignment at one time

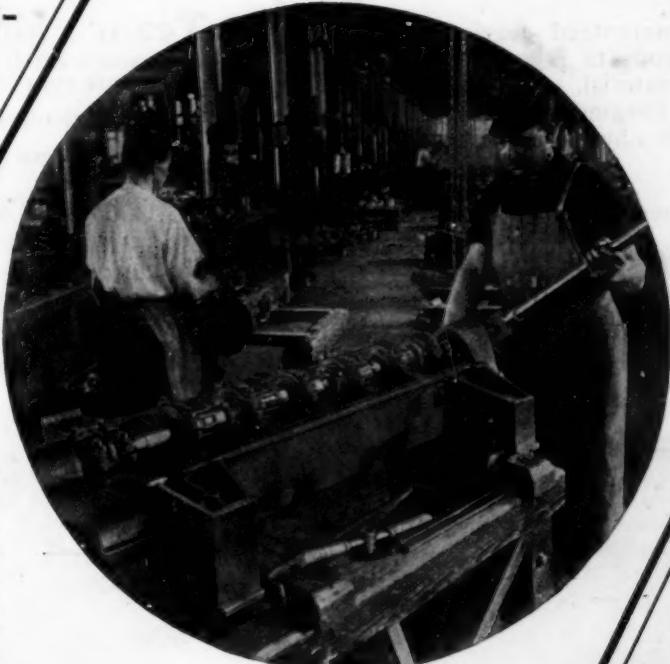
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Bearing Alignment within .00025 at a saving of 50% to 90% in time with the

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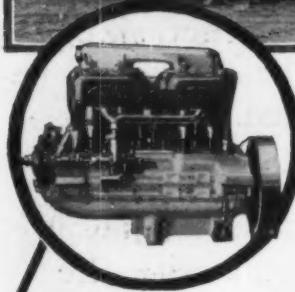
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real efficiency is brought to light. Equipment that fulfills war's demands meets every commercial requirement. The army recently contracted for many thousands of F.W.D. Trucks, equipped with

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For Trucks, Tractors
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Write for specifications
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This signifies Government approval of Wisconsin Motors' continuous, consistent, dependable power. Of proven mastery over every power contingency. The argument that clinches truck and tractor sales.

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With this lubricant fill the gear case *only up to the lowest gear tooth*. One such filling will last for 5000 to 10,000 miles. Each gear tooth is coated. There is less noise, less wear. Thuban sticks, lasts longer, lubricates better.

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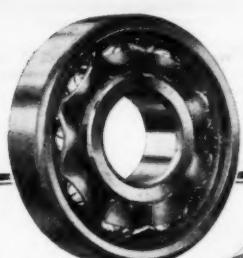
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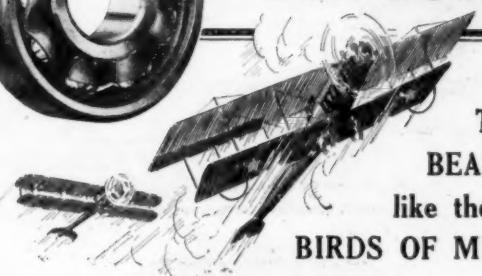
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attached to your tire pump, you will know when to stop pumping. It permits the measuring of the inflation without disconnecting the pump and the tire.

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THIS
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SUSTAINS and carries a load in any direction.

COMBINES strength and durability to withstand the hardest service.

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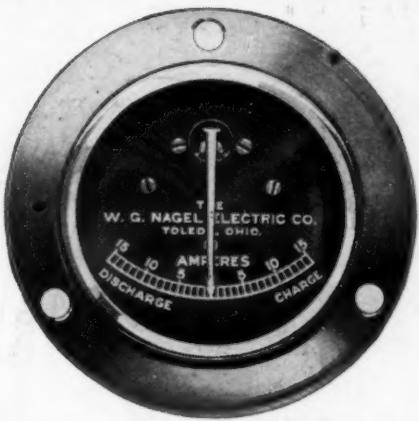
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To Meet INDUSTRIAL and
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Prepare for Peace

Now that peace has been declared, passenger car manufacture, in all probability, will soon assume abnormal proportions. Meanwhile there are trucks and tractors to be turned out, and plans to be made for handling post-war business. But no far-seeing manufacturer will feel that he can now afford to overlook any detail which will make his present cars good and his future ones better.

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Gaskets and Washers**

are made from a cork composition through which liquids simply cannot pass. Their great resilience, moreover, enables them to fill up flange irregularities so that even where metal surfaces are somewhat uneven, no seepage can occur. Their permanent elasticity prevents rattle. Samples of Acco Cork will be cut to your own specifications, free of charge.

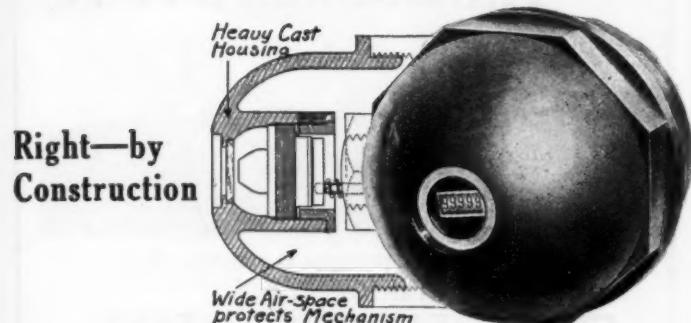
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Branches in the Principal Cities

ACCO

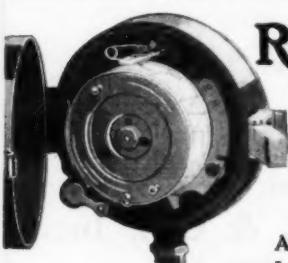
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There is
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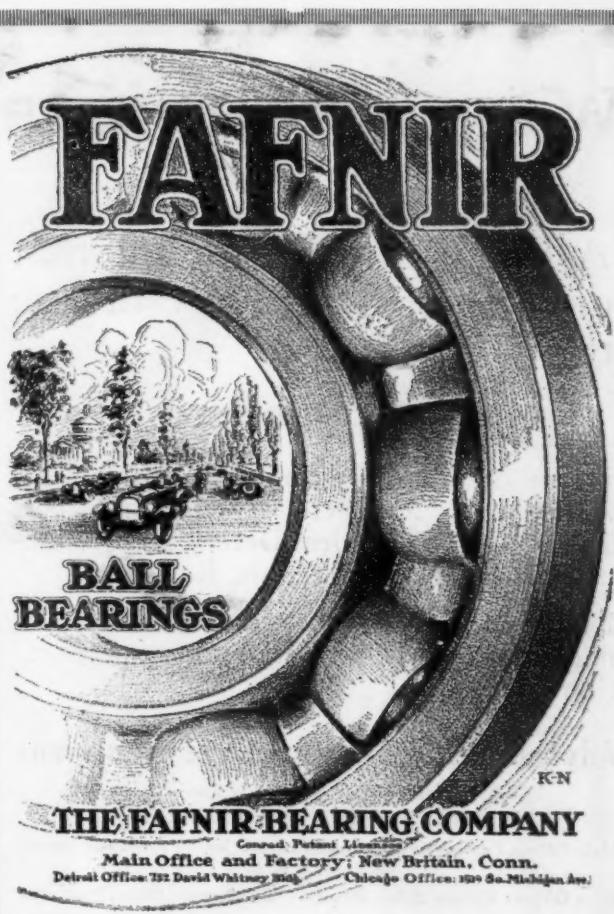


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Let us figure on your contract work.

Scovill Manufacturing Company

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WIDNEY RESILIOMETER

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PATENTS PENDING

A Precision Instrument that enables the world to establish the

First Standard

in the manufacture and use of Compressible Materials—Felt, Rubber, Leather, Paper, Cork, Textiles, Determines Thickness, Hardness, Hysterisis, Resiliency.

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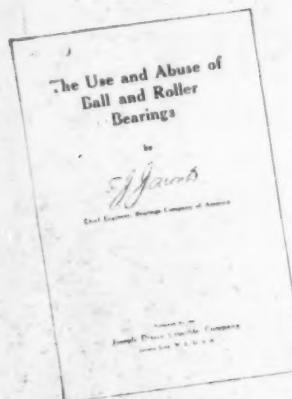
PETER A. FRASSE & CO., Inc.

417-421 Canal St., New York

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Works: Hartford



The Use and Abuse of Ball and Roller Bearings

By
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Chief Engineer
Bearings Company of
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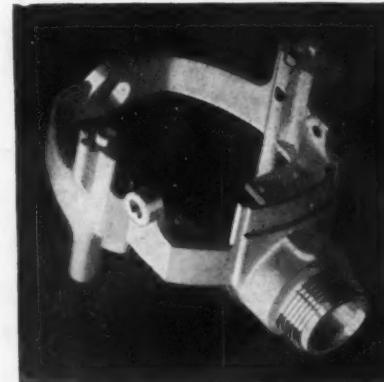
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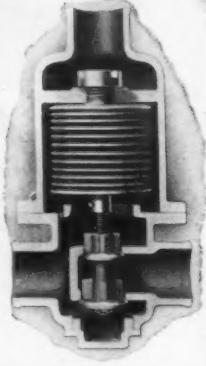
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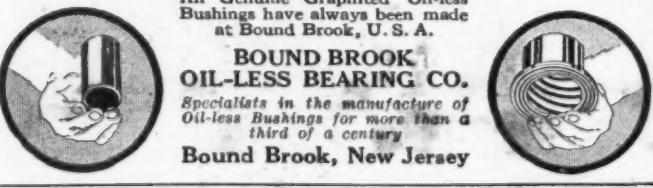


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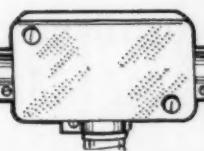
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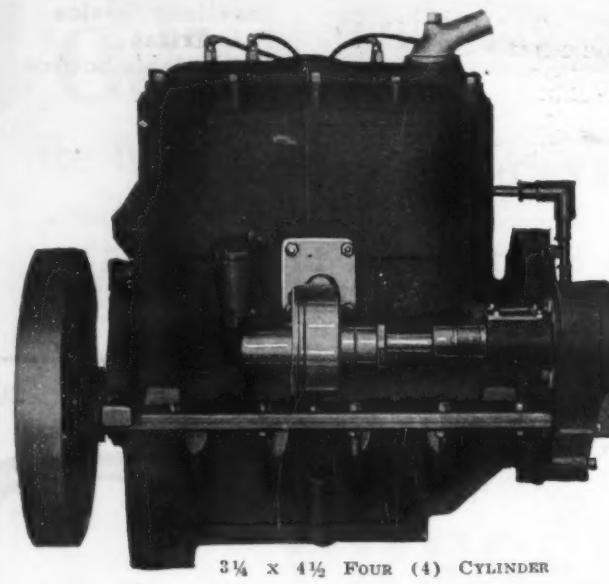
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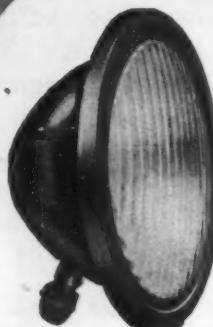
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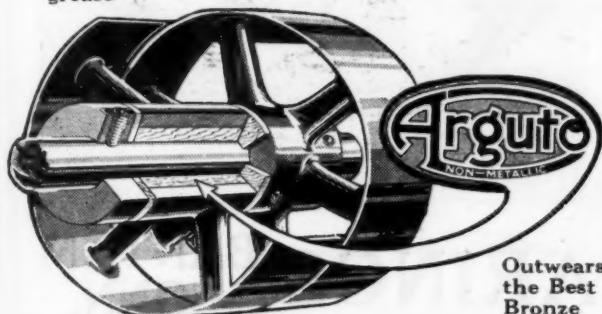
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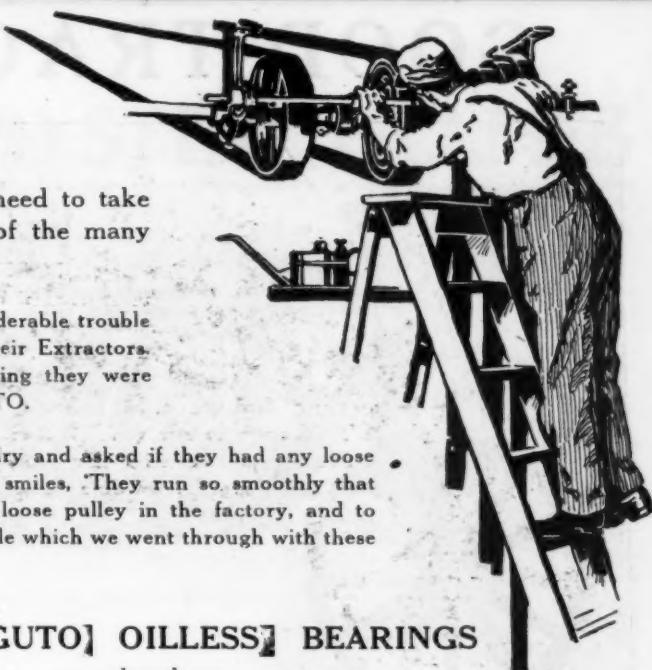
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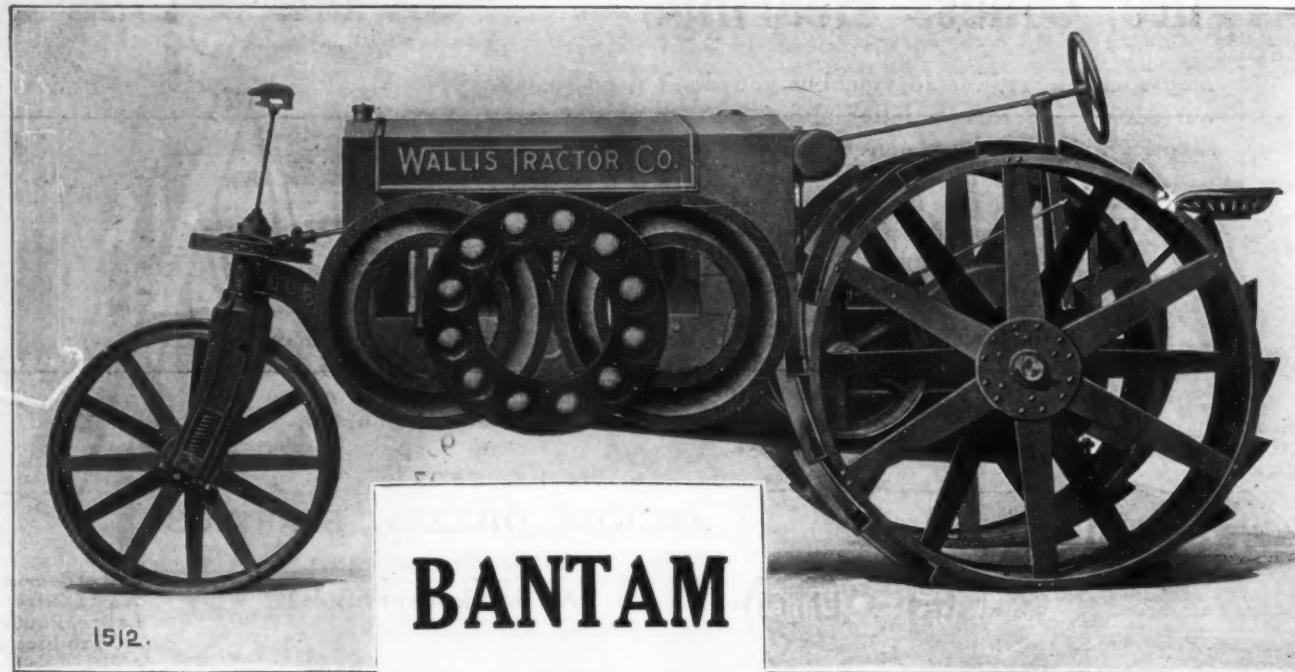
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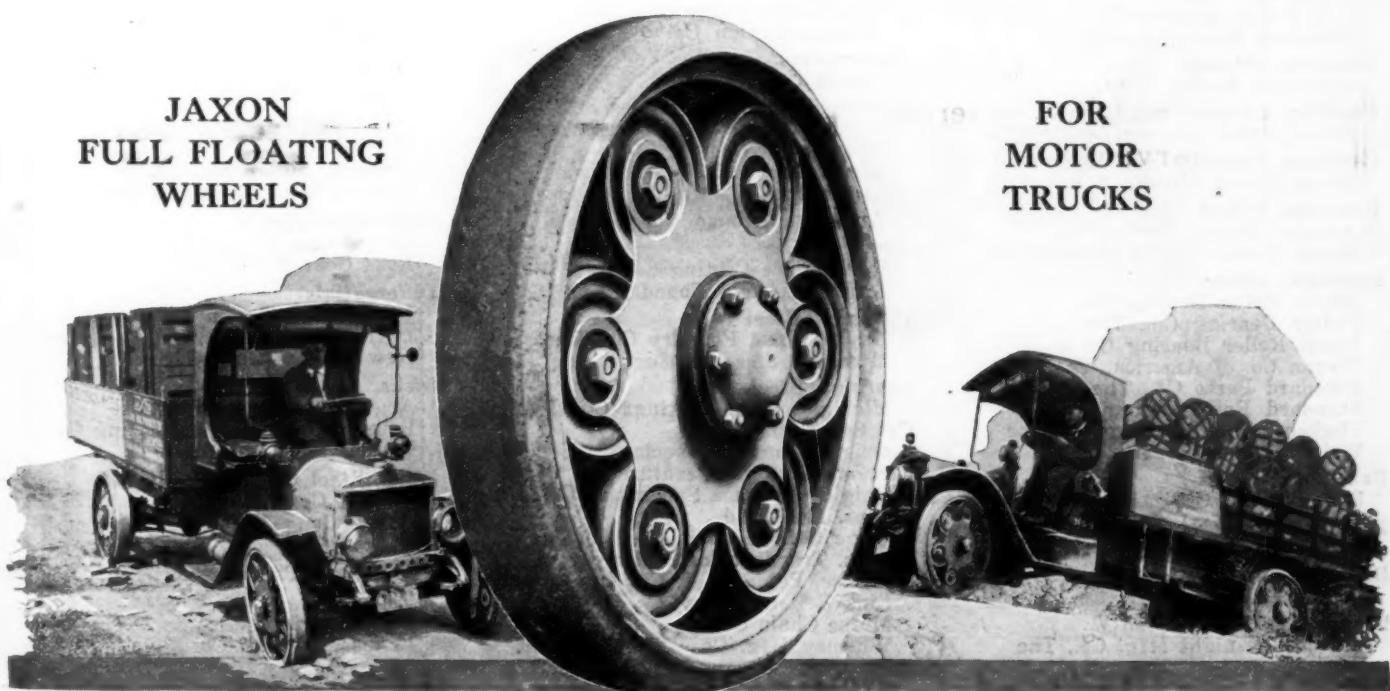
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Thermoid Rubber Co.

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With the Coming of Peace—

we hasten to express to all users of Mogul Bearings our sincere appreciation for the consideration shown us while the pressure of war work, scarcity of materials and delays in transportation made it difficult to render the same satisfactory service as previously. These same obstacles will persist, of course, in a degree for some time, but you may rest assured that as quickly as the situation will permit we will take care of all your requirements for engine bearings on the same basis of service and quality which first won your favor for

Mogul
Bronze Babbitt lined and Die Cast Bearings

The Muzzy-Lyon Company, Ltd.
Detroit - - - - Michigan

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RUSCO BRAKE LINING AND CLUTCH FACINGS



HERE we reproduce a full size photograph of a piece of Rusco Brake Lining cut to show how closely and uniformly the tempered brass wire and selected, long fibre, pure asbestos are interwoven.

This solid web thoroughly impregnated with a special "Rusco" compound making it water, oil, grease, and dirt proof, means extraordinary strength and a never-failing friction surface. All other "Rusco" products are of the same high quality, the result of over 88 years experience in heavy and light web weaving.

Build into your cars and trucks "Rusco" Products, which include "Rusco" Brake Linings, Multiple Disc Clutch Facings, Cone Clutch Facings, Anti-Squeak Webbing and Woven Strapping, and you add that much of quality, serviceability and safety to your products.

The Russell Manufacturing Co.

Home Office and Factory **504 Russell Avenue**
Middletown, Conn.

New York City — 349 Broadway
Chicago — 1438 Michigan Ave.
Detroit — 18 Alexandrine Ave. E.

**38 FACTORY
BUILDINGS**
1000 LOOMS



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WILLARD STORAGE BATTERY

Willard Threaded Rubber Insulation



Do Your Part

The American Army and Navy need batteries—batteries for big trucks, batteries for motor cars, batteries for firing great guns, batteries for air-craft, batteries for the work of the Signal Corps.

Our first duty as battery builders, the first duty of every user, manufacturer and dealer is to see that the Army and Navy get *everything* they need.

If you have to wait for delivery of batteries, remember that the boys across the sea must come first.

Meantime we'll help you every way we can to keep old batteries going as long as possible.

Be sure we both do all we can to keep every single one on the job.

Willard Service.

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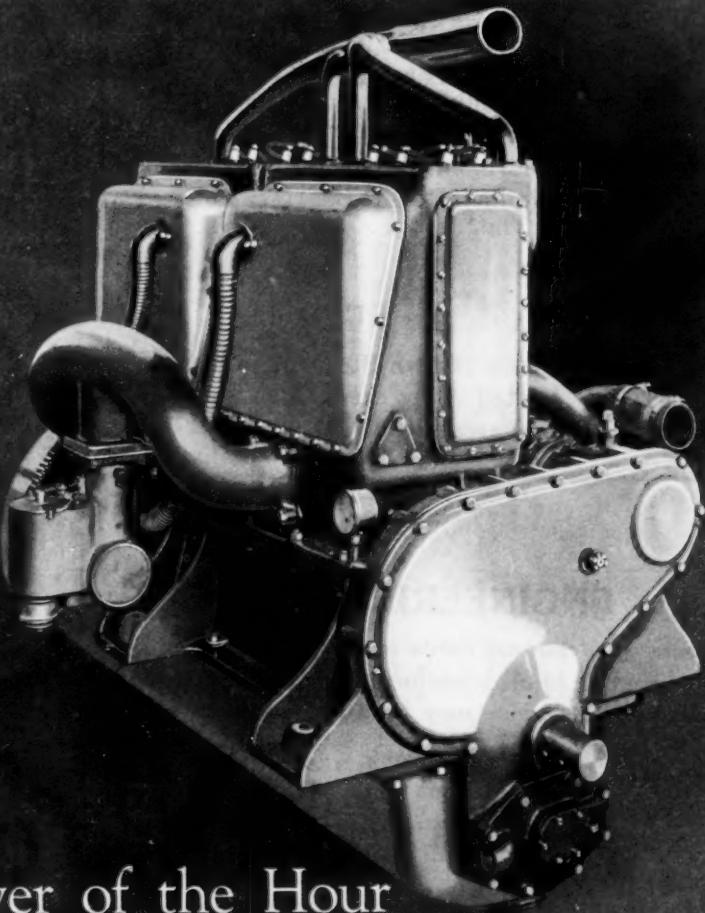
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4 CYLINDERS—BORE 6½"—STROKE 7¾"



The Power of the Hour

160 HP. at 1200 R.P.M.

148 HP. at 1100 R.P.M.

135 HP. at 1000 R.P.M.

120 HP. at 900 R.P.M.

DUESENBERG MOTORS CORPORATION

120 BROADWAY, NEW YORK CITY

CONTRACTORS TO THE UNITED STATES GOVERNMENT

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Research Work
 Automotive Design
 Motor Transportation
 Chemical Testing
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Mechanical Testing
 Automotive Testing
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 Engine Investigation
 Body Engineering

"INDEX TO ADVERTISERS' PRODUCTS"

THE items listed in the classified section of THE JOURNAL represent the products of the best-known companies connected with the automotive industry. Over 246 products manufactured by 133 companies are listed.

Every regular advertiser is entitled to and does have a certain number of his products listed in this "Index to Advertisers' Products." However, only those products which are of direct interest to the members of the Society are included.

S. A. E. Members are assured, therefore, that the list of products appearing on pages 86, 88 and 90 is there strictly for their benefit.



ATWATER KENT

SCIENTIFIC IGNITION

YOUR Atwater Kent system is *constructed* in a mechanical atmosphere the uppermost purpose of which is to produce an instrument of accuracy, precision and durability.

This perfectly synchronized ignition unit will continue to give efficient service long after the motor to which it is affixed has ended its usefulness.

ATWATER-KENT MFG. WORKS *Philadelphia*

SEE YOUR DEALER OR WRITE TO 4948 STENTON AVENUE

MY SOLDIER



Now I lay me down to sleep
I pray the Lord my soul to keep.
God bless my brother gone to war
Across the seas, in France, so far.
Oh, may his fight for Liberty,
Save millions more than little me
From cruel fates or ruthless blast,—
And bring him safely home at last.

BUY WAR SAVINGS STAMPS

COMPLIMENTS OF
CURTISS AEROPLANE AND MOTOR CORPORATION



W.S.S.

W.S.S.

Carry Through Meeting

of the

Automotives

Society Technical Sessions



Victory Dinner

New York
February 4-6



Judge

WINSLOW HOMER

THE FARTHER WEST THE POPULATION WENT THE FARTHER REMOVED WERE EUROPEAN INFLUENCES, UNTIL OUT OF THE ACTION AND INTERACTION OF FRONTIER AND COAST, OUT OF THE INTERPLAY OF SECTION AND OF CLASSES, THERE CAME SOMETHING DIFFERENT, A DEVELOPMENT OF LIFE AND INSTITUTIONS WHICH HAS BECOME KNOWN AS AMERICAN.—(Farrand)

